ISTS Technical Memorandum

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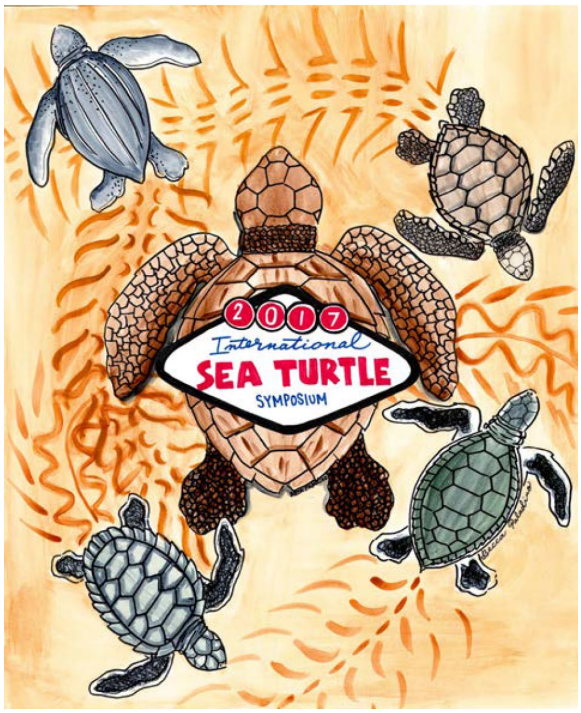
PROCEEDINGS OF THE THIRTY-SEVENTH SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION



15 – 20 April 2017
Las Vegas, Nevada, USA

Compiled by:
Nathan J. Robinson, Laura Fuentes-Tejada, Ruth Doñate Ordóñez, Aliki Panagopoulou, Lisa C. Belsiks, & Joseph B. Pfaller

June 2026

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A PDF version is available on the International Sea Turtle Society website,
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PRESIDENT'S WELCOME

37th Symposium on Sea Turtle Biology and Conservation

15 – 20 April 2017, Las Vegas, Nevada, USA

Frank. V. Paladino

Dear ISTS Attendees:

Thank you for attending the ISTS meeting in Las Vegas, NV USA, April 15 – 20 2017 at the Marriott Resort & Spa. Welcome to the City of Las Vegas which is renowned for its resorts, shopping, dining, and nightlife and is the leading cultural center for Southern Nevada. Welcome to a place where over 1,000,000 people are supplied with 100% renewable energy every day from solar wind and hydroelectric sources. With the theme of climate change I hope that soon many cities will be also able to boast of the use of all clean energy sources! I am very excited about the many workshops, regional meetings and scientific content of this symposium. Our annual meeting will provide us with a great opportunity to celebrate our commitment to sea turtle conservation and research and I am sure we will all have great fun.

This is the first time in the history of our Society that the Symposium will take place in this great city in the desert. We are situated at the heart of the Mojave Desert, surrounded by mountain ranges on all sides and are just a few miles from the Red Rock Canyon and an hour's drive from Hoover Dam. The Grand Canyon National Park is a stone's throw away from the city. I hope that our many international participants will get a chance to explore the desert southwest of the USA and of course the many aspects of Las Vegas itself. I am sure we will all learn a lot about turtles, climate change, and conservation of our ocean resources.

The Symposium's program includes several workshops that will provide opportunities to exchange ideas regarding environmental and sea turtle conservation issues, as well as provide cutting edge information about sea turtle health and rehabilitation. We have a unique opportunity to learn more about freshwater turtles and tortoises at the International Tortoise and Freshwater Turtle Mini-Symposium. We will also have important regional meetings, which will allow participants from over 65 countries around the world to discuss specific problems that impact their regions, and the Annual Marine Turtle Specialist Group Meeting. As per the presentations, the Symposium will include over 140 oral presentations and over 250 posters, organized in sessions that range from physiology to nesting and in-water biology to social and cultural studies.

We also have several fun events lined up, which I am sure we all look forward to: Student social, Speed Chatting with the Experts, Video Night, the brand-new Dance your Research Competition (don't forget to watch the videos and vote for your favorite on line) and of course the Silent and Live Auctions. As you can see, our schedule is full and exciting, and I hope you will enjoy what my hard-working Program and Event staff has prepared for you.

Warmest welcome,

Frank V. Paladino, PhD
President
International Sea Turtle Society

PRESIDENT'S REPORT

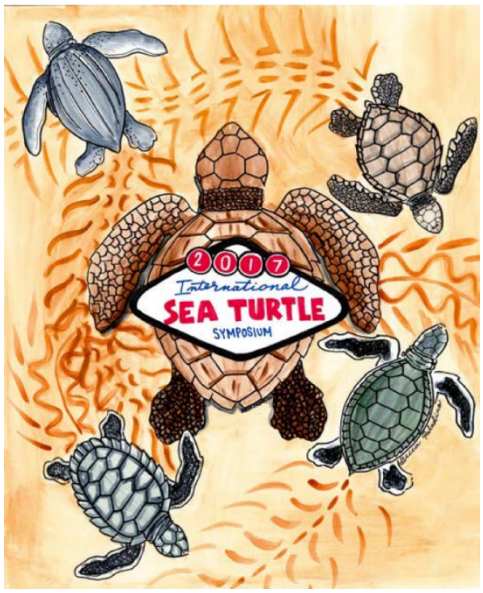
Summary Report - 37th International Sea Turtle Society Symposium (2017)

By Frank V. Paladino, Symposium President

The 37th Annual Symposium on Sea Turtle Biology and Conservation was held in Las Vegas, Nevada from April 15th to 20th, 2017. Las Vegas is renowned for its resorts, shopping, dining, nightlife and serving as a leading cultural center for Southern Nevada, but it is also a city where over 1,000,000 people are supplied with 100% renewable energy every day from solar, wind and hydroelectric sources. Thus, Las Vegas provided a good venue for the international sea turtle symposium, particularly taking into account that this year's symposium theme was Climate Change. Our sea turtle community hopes that soon many cities will be able to boast of the use of entirely clean energy sources.

A total of 790 people registered for the Symposium, all of who came together to learn a lot about turtles, climate change, and conservation of our ocean resources. A total of 136 oral papers and 244 posters were presented at the symposium. The symposium program also included several workshops, regional meetings and the annual marine turtle specialist group meeting.

Several fun and productive social building events were scheduled: Speed Chatting with Sea Turtle Experts, the Student Social Mixer, Video Night, the new Dance your Research Competition, and the Silent and Live Auctions. Overall, the meeting was exciting and a success from every perspective; details are offered below.



Logo: Frank Paladino's daughter Rebecca created this year's symposium logo. The patterns and colors reflect the beaches and sand that are critical to turtles around the world, but which are often impacted quickly with climate change. Rebecca designed this stunning graphic that aptly represents the emergence of new life, new knowledge and the iconic welcome logo of Las Vegas inviting all to share in making the 2017 symposium an event that can be celebrated and remembered for decades to come.

Pre-symposium Workshops & Regional Meetings: The structure of the symposium was similar to past symposia, several pre-symposium workshops and regional meetings were scheduled during the three days prior to the symposium main three days of presentations, providing the opportunity to exchange ideas regarding environmental and sea turtle conservation issues, as well as provide cutting-edge information about sea turtle health and rehabilitation. These meetings were successful and also helped attract attendees early to the symposium.

A total of 12 workshops were held, including: the 3rd Eastern Pacific Leatherback Network (LaudOPO); State of the World's Turtles (SWOT) Team Global Summit; 8th Turtle Medicine; Strengthening Environmental Education in Conservation Projects; Application for Photo-Identification and Emerging Tracking Technologies; Light Management on Nesting Beaches: Identify, Evaluate, Plan, and Execute; Temperature-dependent Sex Determination in Marine Turtles: from Biochemistry to Ecology and Climate Change; Beyond Satellite Tracking Systems: Archival, Acoustic and Radio Telemetry – Exploring the possibilities; Use of Unmanned Aerial Vehicles or Drones (UAVs) in Sea Turtle Conservation and

Research; Sea Turtles and Marine Debris; Hawksbill products in Latin America and the Caribbean; and Future Trends in Sea Turtle Epibiont Research.

A total of seven Regional Meetings were held allowing participants from over 65 countries around the world to discuss specific problems that impact their regions. These were: Africa; East Asia; Eastern Pacific Hawksbill Initiative (ICAPO); Indian Ocean and Southeast Asia (IOSEA); Latin America (RETOMALA); Mediterranean; and Pacific Islands/Oceania. Also, two side meetings were held: the International Tortoise and Freshwater Turtle Mini-Symposium; and the IUCN Marine Turtle Specialist Group (MTSG).

Opening and Keynote Speakers: After the Opening Remarks, the symposium opened with a special Native American ceremony performed by Nakotah LaRance from OhKay Owingeh Pueblo (New Mexico). He performed the spectacular, traditional Hopi Hoop dance celebrating nature and all living things. Two keynote speakers addressed attendees with speeches focused on the symposium theme; Dr. Vincent Saba, of NOAA, gave updated information about Climate Change when he presented "The Current State of Climate Change Science", and Dr. James Spotila, of Drexel University, followed immediately making his talk a personal testimony: "Global Warming and Sea Turtles: A Personal History".

Left: Nakotah LaRance performing a traditional Native American dance. Top Right: Vincent Saba speaking about Climate Change. Bottom Right: James Spotila sharing his experience with sea turtles and global warming.

Drs. Manjula Tiwari, Karen Bjorndal, and Jeanne Mortimer presented a special tribute "Do it like Peter" to Dr. Peter Pritchard, who has attended all 37 symposia since the first meeting was held in 1981 and who has made unparalleled, lasting contributions to the sea turtle conservation community.

Top Left: Manjula Tiwari opening the tribute for Peter Pritchard, followed by Karen Bjorndal (Top Right) and Jeanne Mortimer (Bottom Left). Bottom Right: Peter Pritchard.

Symposium Sessions: The Oral and Poster presentations consisted of traditional session categories, including Anatomy, Physiology and Health; In-Water Biology; Nesting Biology; Population Biology and Monitoring; Fisheries and Threats; Conservation, Management and Policy; Education, Outreach and Advocacy; and Social, Economic and Cultural Studies. A total of 136 oral papers and 244 posters were presented within these categories. Poster presenters had also the opportunity to answer questions and give more details on their presentations during "Meet the Authors".

There were two special sessions. The session "Climate Change" consisted of oral presentations that highlighted the consequences that sea turtles currently face and will face in the future with respect to ongoing climate change. The other special session was "Citizen Science", during which the presentations showcased how the general public can get involved with and assist sea turtle conservation.

Social Events: The social component of the symposium was underscored by the Welcome Social, Student Committee activities, Video Night, Speed Chatting with Sea Turtle Experts, Silent and Live Auctions, Awards Ceremony and the Farewell Banquet.

The Student Committee conducted its 6th year of activities dedicated to welcome and encourage student attendees. This year there was three core activities: Student Presentation Feedback during which 49 evaluators volunteered to give feedback to 156 students (72 oral presentations and 84 posters). The committee hopes to continue doing this activity for the upcoming symposia as they have received many positive comments from students. The second planned activity was a half day workshop "Grant Writing: How to Get Funds", which provided the participants a set of tools to help them write successful grant proposal. Lastly, with the aim to promote networking and communication among students and other

symposium participants, and also enhance their participation in the society, a Student Social Mixer was held the afternoon before the primary symposium sessions. The mixer included the participation of the Society's Board Members, nominees for the current Society's election, as well as renowned sea turtle researchers.

For the Video Night, seven videos were projected to symposium attendees highlighting research, conservation and educational issues from around the world. The Video Night also shared the video entrees from the new Dance your Research Competition.

The lineup for Speed Chatting with Sea Turtle Experts was: Mark Hamann (Sea Turtles and Plastic Pollution); Barbara Schroeder (Conservation Policy and Management); Selina Heppell (Sea Turtle Assessment Modeling); Andrew DiMatteo (Spatial Analysis and Cartography); David Owens (Reproductive Biology of Sea Turtles, Hall of Fame); John Wang (Sea turtle Behavior and Fisheries Bycatch); Justin Perrault (Toxicology and Sea Turtle Health); Sandra Hochscheid (Satellite Telemetry and Tagging); Maria Chadam (Sea Turtle Health and Rehabilitation); and Vicent Saba (Sea turtles and Climate Change).

As is typical, the Silent and Live Auctions were among the most popular events. The events jointly raised over $22,000 to help students to attend future symposium via travel grants.

Images from the Live Auction.

ISTS Awards: Janet Hochella and Jim Stevenson, also known as the J & J Turtle Team, received the Ed Drane Award for Volunteerism for their very long history of volunteerism with many projects throughout the United States and Costa Rica. The SWOT Network and Cristina Ordoñez were awarded the ISTS Champions Award. ISTS Lifetime Achievement Awards were presented to Jean Beasley of Sea Turtle Rescue and Rehabilitation Center, Jack Musick of Virginia Institute of Marine Science, Marydele Donnelly of Sea Turtle Conservancy, and to Fehmida Firdous, nicknamed the "turtle lady" in Pakistan. President's Awards were given to Nakotah LaRance, Brad Nahill and Aliki Panagopoulou for their great service. The Grassroots Conservation Award was given to Paso Pacifico for their ranger community program.

Jean Beasley (Left), and Jack Musik (Right) celebrating their Lifetime Achievement Awards.

Archie Carr Student Awards: There were 40 student oral presentations and 73 student poster presentations nominated for the Archie Carr Student Awards. Eight students won the Archie Carr award for outstanding presentations. Miriam Mueller (Biology-winner), Bethany Holtz (Biology-runner up), Brianna Elliott (Conservation-winner) and Emily Asp (Conservation-runner up) won in the Poster Category. Robert Johnson (Biology-winner), Matthew Ramirez (Biology-runner up), Andrews Agyekumhene (Conservation-winner) and Bianca Santos (Conservation-runner up) won in the Oral Category.

Travel Grants: The ISTS was able to support a total of 120 travel grant applicants with lodging during the symposium. The distribution of bed grant accommodations per region was as follows: 14 bed grants to Africa representatives, 8 to Asia Pacific, 4 to Caribbean, 10 to Europe, 20 to Mexico/Central America, 16 to South America, 12 to South Asia, and 36 to US/Canada. This level of travel grant awards represented about 15.2% of the total registered participants.

Board of Directors Meeting: The Society's Board of Directors got together and discussed reports from the Nominations Committee, Student Committee, Travel Committee, Students Awards Committee, ISTS Awards Committee, as well as reports from the Program Officer and Treasurer.

Plenary Business Meeting and Society Elections: On the last day of the symposium, a Board of Director member presented a draft/proposal for a "Code of Conduct" to be followed by all society's member. Also, the Travel Grant Committee Chair and the Treasurer presented their reports to society members.

The attendees approved both reports. As a result of the 2017 society's annual election, Ken Lohmann from North Carolina (USA) was elected President for symposium 2019, George Balazs as the new ISTS Treasurer, and Manjula Tiwari was reelected ISTS Secretary. Also, the elections added two new members to the Board of Directors, Felix Moncada (2022) and Marc Girondot (2022). They join Yakup Kaska (2018), Emma Harrison (2018), Pamela Plotkin (2018), Mariana Fuentes (2019), ALan Rees (2019), Andrea Phillot (2020), Laura Prosdocimi (2020), Andrews Agyekumhene (2021) and Jeanette Wyneken (2021) (Year indicates board member's end of term). Jesus Tomas and Natalie Wilderman were elected to join the Nominations Committee, and Joana Hancock joined the Awards Committee.

Yoshimasa Matsuzawa, ISTS President 2018, provided details regarding the upcoming symposium to be held in Kobe, Japan. Dates have been designated as 18-23 February 2018, during which time society members will once again convene, in this case celebrating the theme "Beyond Protection of Sea Turtles".

Exhibitors and Vendors: There were a variety of exhibitors and vendors that participated in the Las Vegas symposium. They included: Ayotzintli AC; Bioko Biodiversity Protection Program; Bioko Marine Turtle Ptrogram; CLS America, Inc.; Desert Star Systems LLC; East Coast Observers, Inc.; Ecology Project International; FlyWire Cameras, Inc.; Elcas Lightning; Herding Turtles (Coins, Currency, and Exonumia); Karumbe; Latin American Sea Turtles (LAST); Loggerhead Marinelife Center; Lotek Wireless Inc./Sirtrack Ltd.; Marinelife Alliance; Paso Pacifico; Pro Delphinus; Sea Turtle Conservancy; Southeast Regional Sea Turtle Network; Telonics, Inc.; The Leatherback Trust; The State of the World's Sea Turtles (SWOT); and Wildlife Computers.

Fundraising: Generous funding by many entities made possible the success of the ISTS37. The entire society deeply thanks the following donors for their generosity: At the Gold level ($10,000-$24,999): The Shared Earth Foundation and The Leatherback Trust. At the Silver level ($1,000-$9,999): Disney's Animals, Science & Environment, Sea Turtle Conservancy, International Seafood Sustainability Foundation, Sirtrack & Lotek, George Balazs and Frank Paladino. At the Bronze level ($500-$999): J. Ross Publishing, Team Sympraxis, CLS America, National Save the Sea Turtle Foundation, Bioko Marine Turtle Program, Cefas Technology Limited and Nevada State College.

Acknowledgments: Organizing the Las Vegas symposium took a large number of volunteers allocated in various committees: registrars, fundraising, program, poster, workshop, student, travel grant, awards, exhibitor, volunteer, auction, and proceedings committees. All of these individuals gave significant number of hours, effort and dedication towards their entrusted tasks. By alphabetical order of their first name, the Society thanks Adriana Cortés, ALan Rees, Alberto Abreu Grobois, Alejandro Fallabrino, Alexander Gaos, Aliki Panagopoulou, Amanda Southwood Williard, Amber Rhodes, Ana Barragan, Andrea Phillott, Andrew DiMatteo, Andrews Aguekumhene, Andy Estrades, Angela Formia, Barbara Schroeder, Blair Witherington, Boniventure Mchomvu, Brad Nahill, Brian Hutchinson, Brian Shamblin, Bryan Wallace, Catherine Bell, Chelsea Clyde-Brockway, Conne Ka-Ya Ng, Daniela Freggi, Dave Owens, David Pike, David Rostal, Donna Broadbent, Dustin Baumbach, Elena Finkbeiner, Emma Harrison, Erin Seney, Gabi Blanco, Gabriela Velez-Rubio, George Balazs, George Shillinger, Hal Avery, Hector Barrios- Garrido, Ingrid Yañez, Irene Kelly, Isao Kawazu, Itzel Sifuentes, Jacques Laloë, Jeanette Wyneken, Jeff Seminoff, Jeffrey Mangel, Jennell Black, Jennifer Homcy, Jesus Tomas, Joanna Alfaro, Joe Pfaller, John Wang, Jordan Thomson, Justin Perrault, Karen Eckert, Kartik Shanker, Kate Mansfield, Kelly Stewart,Kristina Drake, Lalith Ekanayake, Laura Gibbons, Laura Prodoscimi, Lisa Belskis, Maggie Muurmans, Maira Proietti, Manjula Tiwari, Marc Girondot, Maria Chadam, Mariana Fuentes, Marina Zucchini, Mario Mota, Mark Hamann, Matthew Godfrey, Michael Jensen, Mike James, Milagros Lopez, Nathan J. Robinson, Neca Marcovaldi, Paolo Casale, Pamela Plotkin, Patricia Villegas, Pilar Santidriàn Tomillo, Randall Arauz, Ray Carthy, Rebecca Lewison, Rhema Bjorkland, Robert George, Rod Mast, Roldan Valverde, Rupika Rajakaruna, Samir Patel, Sandra Hochscheid, Selina Heppell, Shaleyla Kelez, Shaya Honarvar, Simona Ceriani, Sondra Hochscheid, Stephen Dunbar, Takashi Ishihara, Terry Meyer, Thushan Kapurusinghe, Tom Backof, Tomo Egushi, Tomotomi Saito, Vanessa Bezy, Vicent Saba, Wendy Dow Piniak, Yakup Kaska, Yoshi Matsuzawa, Zahirul Islam, Zoë Meletis, and the various volunteers that were assigned on-site.

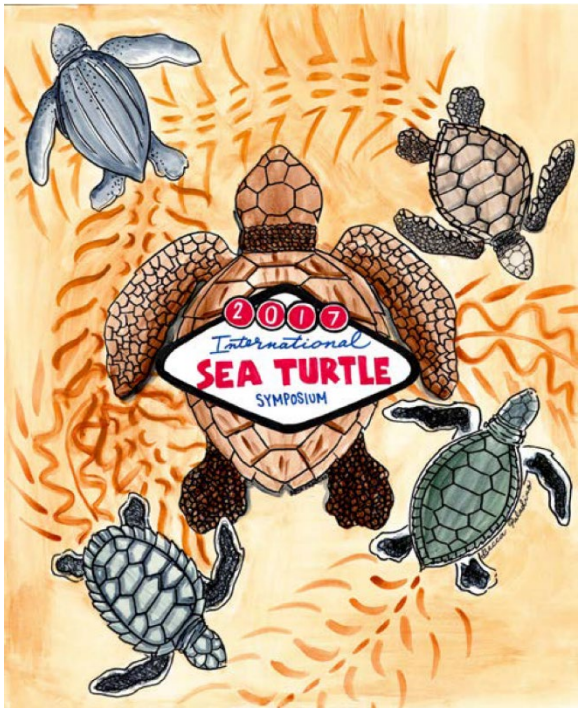
Also, the symposium would not have been possible without the support from the donors mentioned above.

Lastly, the symposium's symbolic rowel was passed from the 37th ISTS President Dr. Frank Paladino (Left) to the incoming 38th ISTS President Dr. Yoshimasa Matsuzawa (Right).

SYMPOSIUM LOGO

This year's Symposium logo was created by Frank Paladino's talented daughter Rebecca Paladino. The patterns and colors reflect the beach and sand which are critical to turtles and beaches around the world and very plentiful here in Las Vegas yet can change quickly with climate changes. The Logo was simplified to adorn this Program and the venue, and the t-shirts consist of only a few colors that represent sand, beaches and turtles. Rebecca designed this stunning graphic that aptly represents the emergence of new life, new knowledge and the iconic welcome logo of Las Vegas inviting us all to share in making the 2017 International Sea Turtle Symposium one that we can all celebrate and remember.

Great work Rebecca - your work is an inspiration to us all!



COMMITTEES, CHAIRS, AND KEY ORGANIZERS

Executive Committee

Executive Committee Role	Member
President	Frank Paladino
Secretary	Manjula Tiwari
Treasurer	Terry Meyer
President Elect	Yoshi Matsuzawa
Past President	Joanna Alfaro

Board of Directors and End of Terms

Board Member	End of term
Roldàn Valverde	2017
George Balazs	2017
Alejandro Fallabrino	2017
Pam Plotkin	2018
Emma Harrison	2018
Yakup Kaska	2018
Mariana Fuentes	2019
ALan Rees	2019
Laura Prodoscimi	2020
Andrea Phillott	2020
Jeanette Wyneken	2021
Andrews Agyekumhene	2021

Organizing Committee

Organizing Committee Role	**Member**
President	Frank Paladino
Symposium Coordinator	Donna Broadbent
Symposium Manager (a.k.a Octopus)	Aliki Panagopoulou
Webmaster	Laura Gibbons (Blue Salamander Solutions, LLC)
Registrar	Elena Finkbeiner, Amber Rhodes
Program Officer (Fundraising)	Ingrid Yañez
Nominations Committee	Kate Mansfield (Chair), Alberto Abreu Grobois, Conne Ka-Ya Ng, Milagros Lopez, and Kartik Shanker
Video Night Chairs	Tom Backof, Catherine Bell
Archie Carr Award Judge Committee	Matthew Godfrey, Andrea Phillott
Grassroots Conservation Award Judge Committee	Ingrid Yañez, Manjula Tiwari, Angela Formia, Alejandro Fallabrino, Colum Muccio
ISTS Awards Committee	Brad Nahill (Chair), Michael Jensen, Thushan Kapurusinghe, Andy Estrades, Blair Witherington
Exhibitor/Vendor Chair	Joe Pfaller
Auctioneer (Live Auction)	Rod Mast
Auction Co-Chairs	Jennifer Homcy, Marina Zucchini
Speed Chatting with the Experts	Hector Barrios-Garrido, Vanessa Bezy, Emma Harrison
Volunteer Co-Chairs	Jennell Black, Daniela Freggi
Student Committee	Itzel Sifuentes, Adriana Cortés
MTSG Group Meeting	Rod Mast, Paolo Casale
International Tortoise and Freshwater Turtle Mini-symposium	David Rostal, Hal Avery and Kristina Drake
Dance Your Research	Kate Mansfield, Neca Marcovaldi
Social Media Support	Andrea Phillott, Alejandro Fallabrino
Photography	Gregory A. Mauger (P & G Studios)

Program Committee

Program Committee Role	Member
Program Chairs	Aliki Panagopoulou, Nathan J. Robinson, Pilar Santidrián Tomillo
Program Coordinator	Ana Barragan
Program Committee	Randall Arauz, Ana Barragan, Hector Barrios-Garrido, Dustin Baumbach, Catherine Bell, Rhema Bjorkland, Gabi Blanco, Stephen Dunbar, Tomo Egushi, Daniela Freggi, Mariana Fuentes, Robert George, Marc Girondot, Selina Heppell, Shaya Honarvar, Takashi Ishihara, Thushan Kapurusinghe, Isao Kawazu, Irene Kelly, Jacques Laloë, Rebecca Lewison, Jeffrey Mangel, Kate Mansfield, Zoë Meletis, Mario Mota, Brad Nahill, David Pike, ALan Rees, David Rostal, Vince Saba, Tomotomi Saito, Jeff Seminoff, George Shillinger, Jordan Thomson, Manjula Tiwari, Jesus Tomas, Jeanette Wyneken, Ingrid Yañez
Session Chairs	Anatomy, Physiology & Health: Jeanette Wyneken, David Rostal, Robert George, Isao Kawazu Conservation, Management & Policy: Mario Mota, Manjula Tiwari, George Shillinger, Daniela Freggi Education, Outreach & Advocacy: Ingrid Yañez, Thushan Kapurusinghe, Brad Nahill Fisheries & Threats: Rebecca Lewison, Takashi Ishihara, Jeffrey Mangel, Randall Arauz In-Water Biology: Jeffrey Seminoff, Gabriela Blanco, Jordan Thomson, Kate Mansfield Nesting Biology: Shaya Honarvar, ALan Rees, Ana Barragan, Tomotomi Saito Population Biology & Monitoring: Rhema Bjorkland, Selina Heppell, Tomo Egushi, Marc Girondot Social, Economical & Cultural Studies: Zoë Meletis, Hector Barrios-Garrido & Irene Kelly Special Theme: Citizen Science: Stephen Dunbar, Jésus Tomás, Dustin Baumbach & Catherine Bell Special Theme: Climate Change: Vince Saba, Mariana Fuentes, Jacques Laloë, David Pike
Poster Session Chairs	Samir Patel, Chelsea Clyde-Brockway
Printed Program	Aliki Panagopoulou, Donna Broadbent, Kelly Stewart, Michael Jensen
Abstract Compilers	Shaya Honarvar, Samir Patel, George Shillinger, Joe Pfaller
Proceedings Compilers	Nathan J. Robinson, Laura Fuentes-Tejada, Ruth Doñate Ordóñez, Aliki Panagopoulou, Lisa C. Belskis, & Joseph B. Pfaller

Travel Grant Committee

Travel Grant Committee Role	**Member**
Chair	Alexander Gaos
Regional Chair – Africa (except North Africa)	Angela Formia
Regional Chair – Caribbean (English speaking)	Karen Eckert
Regional Chair – Mexico, Central America, and Spanish-speaking Caribbean	Emma Harrison
Regional Chair – North Africa, and Middle East	ALan Rees
Regional Chair – Europe	Aliki Panagopoulou
Regional Chair – South America	Alejandro Fallabrino
Regional Chair – South Asia	Andrea Phillot
Regional Chair – Southeast Asia/Pacific	Maggie Muurmans
Regional Chair – USA and Canada	Kelly Stewart

Regional Meeting Organizers

Regional Meeting	**Organizer**
Africa	Manjula Tiwari, Angela Formia, Andrews Aguekumhene, Boniventure Mchomvu
East Asia	Yoshi Matsuzawa
Indian Ocean and Southeast Asia (IOSEA)	Lalith Ekanayake, Zahirul Islam
Pacific Islands/Oceania	Irene Kelly
Latin American Meeting (RETOMALA)	Alejandro Fallabrino, Gabriela Velez-Rubio, Maira Proietti
Mediterranean Reunion	Sandra Hochscheid, Yakup Kaska, Aliki Panagopoulou
ICAPO	Alex Gaos, Ingrid Yañez

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Paso Pacifico
Pro Delphinus
Sea Turtle Conservancy
Southeast Regional Sea Turtle Network
Telonics, Inc.
The Leatherback Trust
The State of the World's Sea Turtles (SWOT) – Oceanic Society
Widecast – Latin American Sea Turtles (LAST)
Wildlife Computers

ISTS AWARDS

ISTS Lifetime Achievement Awards

Marydele Donnelley

Introduced to sea turtles by Archie Carr in Costa Rica, Marydele Donnelley transitioned from primate biology to marine conservation. At The Ocean Conservancy, she was instrumental in securing legislation requiring Turtle Excluder Devices (TEDs) in shrimp trawls. She played a major role in blocking proposals to reopen international trade in sea turtle products and helped end Japanese imports of hawksbill shells. Her efforts contributed to lighting regulations and funding for the Archie Carr National Wildlife Refuge. A driving force behind the Marine Turtle Conservation Act, she has worked extensively with the IUCN Marine Turtle Specialist Group and the ISTS, mentoring young conservationists. She currently serves with the Sea Turtle Conservancy.

Jack Musick

A pioneering figure in sea turtle and shark research since the late 1960s, Jack Musick produced a lifetime of work in marine biology, conservation, and policy. His contributions shaped federal and international protections for sea turtles, and he mentored multiple generations of researchers and policymakers. A founding member of the ISTS, he drafted its first bylaws and helped establish it as a formal society. He served as ISTS Symposium President in 1995 and on the Board of Directors from 1991 to 2000. As Virginia's state coordinator for the Sea Turtle Stranding and Salvage Network, he played a crucial role in assessing sea turtle bycatch and fisheries interactions. He received numerous accolades, including the Commonwealth of Virginia's Lifetime Achievement Award in Science, the American Elasmobranch Society's Distinguished Fellow Award, and the American Fisheries Society's Distinguished Service Award.

Jean Beasley

Jean Beasley is the Executive Director of the Karen Beasley Sea Turtle Rescue and Rehabilitation Center in Topsail Island, North Carolina. With over three decades of conservation work, she has rehabilitated more than 40 injured or sick sea turtles annually. She founded a program to monitor nesting activity, protect nests, and engage in extensive educational outreach. Her leadership in organizing public turtle releases and engaging the local community has inspired a broad volunteer network. She has been an active member of ISTS, attending numerous symposia and serving in various leadership roles.

Fehmida Firdous

Known as Pakistan's "Turtle Lady," Fehmida Firdous has been a passionate advocate for sea turtle conservation since 1980. She has protected over 2.5 million eggs and released more than 700,000 hatchlings along Karachi's Hawk's Bay and Sandspit beaches. Having tagged over 7,000 turtles, she was the first in Pakistan to deploy satellite transmitters on green turtles. Her public outreach efforts have educated thousands of visitors at turtle hatcheries. With over 35 research publications, she has participated in numerous conferences and received national and international recognition. In 2007, she

was awarded Pakistan's highest civilian honor, the Pride of Performance. She holds the distinction of being the first Pakistani to earn a PhD focused on marine turtles.

ISTS Champions Awards

SWOT Network

Founded in 2003 by Rod Mast, Brian Hutchinson, and others, the State of the World's Sea Turtles (SWOT) Program is administered by the Oceanic Society in collaboration with Duke University's OBIS-SEAMAP and the IUCN Marine Turtle Specialist Group. SWOT has played a pivotal role in coordinating global sea turtle conservation efforts, creating the first global database of sea turtle biogeography, producing the first global-scale maps of sea turtle distribution, and establishing minimum data standards for nesting beach monitoring. Through its award-winning SWOT Report, the initiative provides scientifically sound yet accessible conservation insights, distributing thousands of copies worldwide for education and outreach. The network, known as the "SWOT Team," connects hundreds of researchers and conservationists across diverse sectors, from local beach workers to government officials and academics. Since 2006, SWOT has also supported priority conservation projects through its small grants program. For its significant contributions to sea turtle conservation, SWOT was unanimously recommended for the 2017 Champions Award.

Cristina Ordoñez

Cristina Ordoñez has led two highly successful projects focused on the protection and recovery of leatherback and hawksbill sea turtle populations in Bocas del Toro Province and the adjacent Comarca Ngäbe-Buglé along Panama's Caribbean coast. Her work covers nearly 100 miles of nesting beaches, where she has trained numerous international volunteers and local community members, many of whom have become conservation leaders in the region. Ordoñez has authored key scientific papers on her conservation efforts and built strong partnerships with indigenous leaders, environmental authorities, and local law enforcement. She has played a critical role in securing a renewed agreement for the Sea Turtle Conservancy's work in the Comarca and remains a dedicated advocate in the fight against poaching, persistently engaging with national police to enhance protection efforts on the beaches.

Ed Drane Award for Volunteerism

Janet Hochella

A dedicated volunteer since 2003, Janet Hochella has worked extensively with the University of Central Florida's Marine Turtle Research Group and other conservation projects across the U.S. and Costa Rica. Despite personal health challenges, she remains active in tagging, research, and public outreach. Her commitment spans numerous organizations, where she has educated diverse audiences on turtle conservation.

Jim Stevenson

Jim Stevenson has been a devoted sea turtle volunteer since 1980, contributing to research and conservation through the UCF Marine Turtle Research Group and various other organizations. His work includes tagging turtles, scouting for conservation programs, and attending international symposia. His efforts have significantly expanded mark-recapture data on high-density nesting beaches.

ISTS President's Awards

Brad Nahill

James Spotila

Vincent Saba

Fidel Esomo Mba Eyono

Jesus Mba Mba Ayetebe

Aliki Panagopoulou

Grassroots Conservation Award

Paso Pacifico in Nicaragua: Community Ranger Program in Nicaragua: Protecting Sea Turtles, Reducing Poaching Rates, and Empowering Women

Archie Carr Student Awards

Biology (Oral and Poster)

Category	Prize	Student	Institution	Presentation Title
Biology Oral	Winner	Robert Johnson	University of Florida, USA	Green turtles and blue carbon: Effects of grazing on seagrass meadow carbon dynamics.
	Runner up	Matthew Ramirez	Oregon State University, USA	Kemp's ridley sea turtle habitat use and diet variation revealed through combined trace element and stable isotope analysis.
Biology Poster	Winner	Miriam Mueller	National Autonomous University of Mexico, Mexico.	Effects of maternal origin, morphology and incubation temperature on the swimming performance of olive ridley turtle hatchlings.
	Runner up	Bethany Holtz	Gettysburg College, USA	The role of environmental acoustic cues in sea finding of hatchling loggerhead sea turtles.

Conservation (Oral and Poster)

Category	Prize	Student	Institution	Presentation Title
Conservation Oral	Winner	Andy Agyekum hene	University of Cape Coast, Ghana.	Sea turtle bycatch reduction in Ghana's gillnet fishery.
	Runner up	Bianca Santos	College of William and Mary, USA.	Consequences of drift and decay of sea turtle carcasses for the estimation of turtle mortality locations from stranding data in the Chesapeake Bay.
Conservation Poster	Winner	Brianna Elliott, Duke	University, USA.	Trends in sea turtle bycatch following the implementation of an incidental take permit in North Carolina estuarine waters.
	Runner up	Emily Asp,	Coastal Carolina University, USA.	The effects of artificial light pollution upon Caretta caretta hatchling orientation in the Grand Strand and surrounding Central Long Bay Region, South Carolina.

REMARKS, GUESTS, AND KEYNOTE ADDRESSES

Opening Remarks:

Frank V. Paladino – Welcome to the 37th ISTS

Guests:

Nahotah LaRance - Hopi/Tewa/Assiniboine Hoop Dancer from OhKay Owingeh Pueblo, New Mexico

Keynote Addresses:

Vince Saba - "The Current State of Climate Change Science"
James Spotila - "Global Warming and Sea Turtles: A Personal History"
Manjula Tiwari, Karen Bjorndal, Jeanne Mortimer - "Do it like Peter" Special tribute to Peter Pritchard presented by

SPECIAL FEATURES

Special Sessions

1. International Tortoise and Freshwater Turtle Mini-symposium

Organizers: David C. Rostal, Hal Avery, Kristina Drake

Description: This workshop is designed to provide biologists with basic information on working with tortoises and freshwater turtles versus sea turtles. Many sea turtle biologist work in areas where tortoises and other unique freshwater turtles also exist. Some aspects of sea turtle biology are applicable to non-marine turtles but tortoises and freshwater turtles provide their own distinct set of challenges. These challenges as well as research findings will be discussed in detail by different researchers from around the globe. Basic biology, physiology, genetics, incubation and TSD, and health of tortoises and freshwater turtles will be discussed. Research techniques and questions will also be discussed. The goal of this mini-symposium / workshop is to bring together tortoise and freshwater turtle researchers with sea turtle researchers to share commonalities as well as differences in working with tortoises / freshwater turtles versus sea turtles. Talks will be 30-40 minutes plus 5 to 10 minutes for questions. As an overall goal, we want to provide an opportunity for sea turtle biologist from other areas to learn more about other species in the neighboring habitats to their nesting beaches. Tortoise and freshwater turtle researchers and veterinarians such as Dr. David Rostal, Dr. Kristina Drake, Dr. Terry Norton, Dr. Justine Congdon whose research from the E.S George is well known, Dr. Sean Doody *inscuplta*, Bill Boarman, Peter Hudson, Taylor Edwards, Brian Henen and others are scheduled to speak.

Workshops

2. State of the World's Sea Turtles

Organizers: Roderic Mast, Brian Hutchinson, Bryan Wallace, Andrew DiMatteo, Patricia Villegas

Description: The workshop will be the first ever official gathering of the SWOT Team, a global volunteer network of over 1000 sea turtle researchers and conservationists from >100 countries. The State of the World's Sea Turtles (SWOT) program is an ambitious partnership that has convened the SWOT Team and developed a multitude of tools to coordinate, strengthen, and empower sea turtle conservation efforts globally. Managed by Oceanic Society in collaboration with Duke University's OBIS-SEAMAP and the IUCN-SSC Marine Turtle Specialist Group, SWOT is focused at the global scale, recognizing since 2003 that local and regional scale data alone are not enough to monitor trends in abundance and relative threats to turtles, nor to design and implement solutions to insidious threats such as climate change. SWOT is developed around three mutually reinforcing themes: 1. A comprehensive, useful, and usable database of geo-referenced bio-geographical information on all seven sea turtle species; 2. A participatory global network of volunteer partners (the SWOT Team) who regularly update and use the database in an open-source fashion, and; 3. A communications and outreach effort and small grants program that uses SWOT Report and other tools to generate greater awareness and support for sea turtle and marine conservation issues.

3. 8th Medicine Workshop

Organizers: Daniela Freggi, Mariluz Parga, Antonio Di Bello

Description: Sea turtle rehabilitation represents a challenge that more and more facilities are facing around the world, in many areas with a lack of sufficient resources. The implementation of new medical procedures, protocols and surgical techniques needs to be shared among the rescue centers of the different countries and this workshop is designed to be an opportunity for rehabilitators, veterinarians and biologists directly involved in sea turtle medical care in order to share experiences and knowledge related to medicine, rehabilitation and health issues. This is also a unique opportunity for experts coming from different countries to compare and share techniques and treatments, as well as to develop common international projects, ideas, protocols. In the first part, we plan to have lectures from experienced professionals in an open forum format to allow a free-flowing discussion between lecturers and attendees. The workshop will be focused on critical care and emergency medicine, diagnostics, anesthesia and surgery, husbandry, and other topics designed for a general audience. In the second part, we plan to offer the chance to "Meet your Specialist", where participants will have the opportunity to directly discuss particular individual cases with experts.

4. Strengthening Environmental Education in Conservation Projects

Organizers: Georgina Zamora, Antonio Trujillo, Anjelika Abou Issa

Description: Sea turtles play a major ecological role by transferring nutrients to nesting beaches, helping maintain species diversity in the ocean and providing an indication of water quality, among others. They also represent one of the most charismatic species in the ocean, providing the motivation for countless environmental movements and campaigns and, acting as emblems and community symbols. From a more educational perspective, sea turtles have the power to change people's attitudes towards the environment; thus, it's incredibly valuable to use them as stewards of marine ecosystems. Through our field work from France to Panama to Mexico, we noticed that EEPs (Environmental Educational Programs) on sea turtle projects are lacking formality, structure, professionalism, sharing tools and evaluation processes. Our workshop is an initiative for a long-term process in order to strengthen and develop environmental education among the sea turtle conservation community. Our workshop will have four major goals: (1) Building an environmental education program. (2) Evaluating and testing educational tools. (3) Sharing existing educational tools through a database platform Sea Turtle Edu. (4) Creating an environmental education community on sea turtles. Our group supports an active education method, during which the participants are encouraged to ask questions and conduct investigations to find answers. The idea of our workshop is to create an atmosphere for debates where the participants design a list of specific educational requirements to deal with their local environmental issues. Through those debates, we will assist participants structuring their own educational program. During the course of this workshop, participants will construct different educational tools (such as theatre plays, scientific experiments, installations or games) that are relevant to their local communities targeting their environmental needs. The participants will also have an opportunity to have their tools evaluated and improved by professionals in the field. At the end of the workshop, we will put together a mind map of all those participants' tools, which they can continue to develop and spread in their communities.

5. Photo ID and Emerging Tracking Technologies

Organizers: Stephen G. Dunbar, Claire Jean, Andy Estrades

Description: The combined use of digital photographs and new computer technologies have allowed the recent emergence of computer-assisted Photo-ID (PID) in the sea turtles research and conservation community. These technologies represent new non-invasive ways to re-identify individual sea turtles over many years, and have the potential to allow researchers to discover trends of turtle movements, sightings, and habitat use, and to provide vast expansions in our ability to combine these technologies with additional and emerging tracking technologies, such as smartphone apps and computer-based maps. When these technologies are combined with the power of citizen-science, there is potential to move real-time data collection to the global scale, and provide vast sums of data to the sea turtle research and conservation community. These data may allow us to begin asking global-scale questions and address global-scale sea threats to sea turtles. This workshop will continue to develop the theme of PID that was begun at the PID Workshop at the 36th ISTS in Lima, Peru, and will combine PID with other emerging tracking technologies. The workshop will provide opportunities for researchers to present their latest efforts in relation to PID and new tracking technologies, as well as unveil the new Internet of Turtles computer technology for the global sea turtle database developed by Wildbook in partnership with WWF, SWOT, TORSOOI, and ProTECTOR Inc. The workshop will also provide opportunities for small groups to discuss new technologies with experts and develop plans to implement PID and new technologies into their own research and conservation projects. The workshop will also be a lead-in to the half-day session on "Novel technologies and approaches to citizen-science and sea turtle conservation."

6. **Light Management on Nesting Beaches– Identify, Evaluate, Plan, Execute**

Organizers: Lauryn Wright, Rachel Tighe, Rick Herren

Description: Artificial beachfront lighting confuses and disorients both adult and hatchling sea turtles. The result is fewer females emerge on lighted beaches and hatchlings expend valuable energy wandering in the wrong direction, sometimes dying in the process. Removing bright full-spectrum lights and installing sea turtle friendly versions is one of the few ways we can sensibly fix human-caused problems on the nesting beach. However, the process of identifying, evaluating and fixing problematic lights can be confusing and daunting for beachfront owners, local officials and managers of nesting projects. The goal of this workshop is to present the latest information in light management and lighting technology to a diverse group of international stakeholders who can use it to develop or enhance their own conservation programs. Since the Deep Water Horizon Oil Spill in the Gulf of Mexico in 2010, the Sea Turtle Conservancy has been a leader in correcting problematic lighting in Florida. In addition, other key organizations, including the Florida Fish and Wildlife Conservation Commission and the International Dark Sky Association, have played a significant role in educating, evaluating and retrofitting lights along the states beaches. These organizations as well as a handful of other lighting experts will present and discuss the best management strategies to identify problem areas, conduct lighting surveys, choose turtle friendly lights and fix them on new and existing beachfront properties.

7. **Temperature-dependent Sex Determination in Marine Turtles: from biochemistry to ecology & climate change**

Organizers: Marc Girondot, Matthew H. Godfrey

Description: After the success of the three previous TSD workshops (New Orleans, Louisiana, Dalaman, Turkey, and Lima, Peru), the fourth TSD workshop will be organized as part of ISTS 37 in Las Vegas, USA. Temperature-dependent sex determination in reptiles was discovered more than 40

years ago, first in a lizard, then in a tortoise and a freshwater turtle and later in all marine turtles. TSD research has been particularly focused on the biochemical pathway(s) of sex determination and it is been partially solved: Temperature regulates the transcription of the aromatase gene and the aromatase enzyme transforms testosterone to estradiol, the latter being the feminizing hormone (in short!). However, the impact and interpretation of temperature dependent sex determination with field data has been much more complicated. Up to now, it is impossible to estimate sex ratio with certitude using a time series of temperatures taken from beach sand or from within a nest. New solutions will be presented. This workshop will be a mix of presentations and best practices when analyzing sex ratio and temperatures.

8. Beyond Satellite Systems. Archival, Acoustic and Radio Telemetry: Exploring the possibilities

Organizers: Mitchell Sisak, Padraic O'Flaherty

Description: As the technology employed in the various satellite-based (i.e. Argos, GPS, Globalstar) telemetry platforms continue to evolve, they become smaller and more energy-efficient expanding their suitability for their use on a broader range of species and life-stages. Though satellite technologies represent extremely useful tools for researchers by providing invaluable insight into animal movement, they are often found lacking when temporally or spatially fine-scale data is required. In this workshop, we will update attendees regarding recent advances in acoustic, radio and archival telemetry platforms. Newly released and planned satellite products will be discussed. Along with the increased capabilities and reductions in energy consumption and form factor of new families of telemetry tools, basic principles of operation of these devices will also be presented. The practical application of the information presented will be more fully explored during a Q&A session to be held during the last segment of the workshop. This Q&A session will encourage attendees and workshop presenters to both share their experiences and to gain a more complete insight into the benefits and the demands associated with each type of technology. A more complete understanding of the principles of operation and the availability of technology combined with shared experience will empower participants enabling them to determine if their particular research questions can be answered by currently available technology and how best to apply that technology to deliver the data they require. Along with identifying technology to meet research needs, information exchange of this type often results in the development of completely new research questions precipitated by the discovery of the availability of new technological tools.

9. Use of UAVs (Unmanned Aerial Vehicles or Drones) in Sea Turtle Conservation and Research

Organizers: ALan Rees, Miguel Varela, Brendan Godley

Description: The half-day session is intended to bring together sea turtle researchers that are experienced, novice and just interested in using UAVs or drones. The primary aim is to initiate a dialogue on the best use of UAVs for sea turtle studies and catalyze a network where technical advances and method development are shared. The session would be divided into three parts. (1) Introduction to UAVs and technology a. Types of UAV, their general properties b. Data capture options c. Data processing software options. (2) Examples of UAV research a. General outline of basic research topics b. Presentations of UAV research undertaken by workshop organisers and participants. (3) Discussion a. UAV technology - open source / closed source systems b. Methods elaboration and resources c. Legalities of UAV use. The workshop is envisaged to be repeated and developed over successive years/ symposia so that the international sea turtle community are kept

up-to-date with advances in UAV-based research and 'recruits' to the field have opportunity to learn from experienced practitioners first hand.

10. Sea Turtles and Marine Debris

Organizers: Daniel González-Paredes, Alejandro Fallabrino, Gabriela Veléz-Rubio, Natalia Teryda

Description: This workshop is aimed specifically to scientists and researchers who are interested in the subject of the interaction between sea turtles and marine debris. Anthropogenic debris accumulation in marine environments has become a serious problem in the last decades. An increase in the amount of debris, in special plastics, has been reported in all the oceans. Sea turtles interact with marine debris in all their life stages and in different geographic areas. These interactions may cause lethal effects in sea turtles and other marine species. Due to the high levels in turtle mortality for this cause in the last years, it is becoming one of the most important threats these species face. Therefore, it is essential to strengthen research and conservation actions to mitigate and reduce this impact. This workshop is an excellent opportunity to exchange ideas and experiences with the specialists in the matter. International experts will present the current global panorama and the edge research in the matter.

11. Hawksbill products in Latin America and the Caribbean

Organizers: Brad Nahill, Wallace J. Nichols

Description: The sale of hawksbill shell products remains a significant threat to the species across Latin America and the Caribbean. The new campaign "Too Rare To Wear" is being launched to address this issue in the travel and conservation communities. The workshop will bring together representatives from around the region to coordinate surveys to determine the current extent of the problem, share outreach materials, and coordinate efforts to reach travelers in key tourist destinations.

12. Future Trends in Sea Turtle Epibiont Research

Organizers: Theodora Pinou, Nathan J. Robinson, Eric Lazo-Wasem

Description: Although a diverse range of sea turtle epibionts has been identified through published lists of collected specimens, we know very little about the interspecies relationships between sea turtle and their epibionts. A changing climate and warming ocean waters are likely to alter the composition of planktonic larvae in the water column and in turn this may impact the recruitment patterns of sea turtle epibionts. This workshop will not only provide an introduction into epibiont identification for new-comers to the field, but it will also provide a venue for global researchers to gather and discuss how to go beyond short descriptive studies and checklists. It will help bring participants together to consider epibionts as putative indicators of marine health, and emerging disease within the context of sea turtle epibiont load. Workshop participants will organize and brainstorm ideas for research that focuses on the development of targeted long-term monitoring or experimental studies that may elucidate symbiotic interactions between the diverse array of epibionts and their sea turtle hosts. The workshop is interdisciplinary because it requires participation by diverse scholars including (but not limited to) invertebrate biologists, marine ecologists and biogeographers, and vertebrate morphologists.

13. Student Committee Workshop: "Grant writing: how to get funds"

Organizers: Itzel Sifuentes, Adriana Cortés

Description: This workshop is for students and everyone interested in learn how to look for funds. Grant seeking is very important when you work in an NGO or community projects where you do not have regular incomes and you rely mostly on grants and in other kinds of contributions. In these cases, our grant seeking and grant writing skills are the best way to secure the success of your organization or project. The purpose of this workshop is giving you some tools to find grant funding opportunities and writing award-winning grant proposals by knowing where to find these opportunities and understanding what funders want to read. We will have speakers representing both sides of the coin: speakers from a grant giving organization telling us what do they look for in a successful application and speakers known to be accomplished grant writers sharing their knowledge about how to write successful projects. Bring your ideas, questions or projects and we can work them all together!

Video Night

FLORIDA SEA TURTLE LICENSE PLATE PROMOTIONAL VIDEO

Presenter/Organization: David Godfrey, Sea Turtle Conservancy, Florida

Description: Sea Turtle Conservancy helped establish the successful Sea Turtle Specialty License Plate in Florida, which is now the second best-selling specialty tag out of nearly 125 available to vehicle owners in the state. Sales of the tag generate nearly $2 million annually to support sea turtle regulatory oversight, law enforcement, research, education and conservation activities benefitting Florida's sea turtles. Up to 30% of the annual funding is allocated to a competitive grants program administered by Sea Turtle Conservancy, which supports the work of researchers and organizations all around Florida. In order to promote the great projects that are supported by the sea turtle license plate, STC created a series of short mini-documentaries featuring some of the projects supported by the tag. This video is a compilation of four of these mini-documentaries.

ISLE OF YOUTH, ISLE OF CHANGE

Presenter/Organization: Katie Thomson, CubaMar (www.cubamar.org), a project of The Ocean Foundation, and For The Sea Productions (www.forthesea.com)

Description: The short film Isle of Youth, Isle of Change, tells the story of Cocodrilo, a small, remote fishing village on Cuba's Isla de la Juventud (Isle of Youth) and its close relationship with the sea. Cocodrilo was founded by sea turtle fishers from the Cayman Islands in 1904 and has since depended on its local natural marine resources for survival. Today, Cocodrilo finds itself at a crossroads as fisheries are declining and youth are leaving the community in search for more opportunities. Additionally, more tourists are visiting Cuba every year making tourism a possibility for Cocodrilo, which has been mostly inaccessible to outside visitors. Isle of Youth, Isle of Change captures community members' stories of Cocodrilo's unique history and opinions about the village's future. The film focuses on the youth, their close ties to the ocean, and their participation in marine conservation activities as part of a local initiative and annual sea turtle festival. It explores marine ecotourism as a possibility for Cocodrilo to create opportunities for the youth while continuing to protect local sea turtle populations and valuable marine and coastal resources. The film was produced thanks to generous support from Conservation Media Group.

SAVING SEA TURTLES: PREVENTING EXTINCTION

Presenter/Organization: InterChange Media Art Production (narrated by Dr. Sylvia Earle)

Description: Late each autumn, hundreds of sea turtles strand on Cape Cod due to hypothermia. For more than 25 years, the New England Aquarium and the Mass Audubon Wellfleet Bay Wildlife Sanctuary have worked together to rescue, rehabilitate and release thousands of these sea turtles, mostly Kemp's Ridleys, the world'smost endangered sea turtle. Over the last decade, the number of stranded turtles has steadily increased, but the late autumn of 2014 saw an unprecedented event as more than 1,200 cold-stunned sea turtles washed ashore. This massive wildlife emergency marshaled an inspiring response that reached from individuals to the federal government involving 10 states and 21 institutions. This feature length documentary also tells the larger natural history story of the Kemp's Ridley and how humans pushed a healthy population to the precipice of extinction and are now slowly helping it to recover.

TOO RARE TO WEAR: TURTLESHELL FOR SALE IN LATIN AMERICA

Presenter/Organization: Brad Nahill, SEE Turtles / Too Rare To Wear

Description: Turtleshell, made from the carapace of the hawksbill sea turtle, is sold across Latin America and the Caribbean as souvenirs for tourists. Too Rare To Wear is leading a campaign to end the demand for these products by engaging the tourism industry. This video will show how turtle shell is made into products like rings and bracelets and sold at markets and souvenir shops in Nicaragua.

MY HAGGAN DREAM

Presenter/Organization: Irene Kelly

Description: The film 'My Haggan Dream,' is a story told through the eyes and voice of a young girl, Kaya, who was born and raised in Saipan. On the island of Saipan, Kaya's mysterious dream about a haggan, or green sea turtle, leads her to investigate the sea turtles that live around her home. Join her adventure to find turtles, which leads to a wonderful birthday wish. This film recently won 1st place in the BLUE Ocean Film Festival (Nov 2016) in the Children's film category, and was created as part of an overarching outreach strategy to combat ongoing poaching pressure in Saipan, CNMI where 40% of nesting females continue to be harvested.

SPATIAL ECOLOGY AND SCIENTIFIC VIDEO ON GALÀPAGOS SEA TURTLES

Presenter/Organization: Juan Pablo Muñoz-Pérez & Daniela Alarcón-Ruales

Description: One day on the life of a Sea Turtle in the Galápagos What do wild animals do when we're not around? From a sea turtle point of view. Find out with the Galapagos National Park (GNP) and the Galapagos Science Center (GSC), the Spatial Ecology and Scientific Video initiative on sea turtles (SESV). Without disturbing sea turtles, this small package of instruments that records important conservation data such as: location, temperature and depth. Including a camera that captures video and sound, giving us extraordinary views in the life of a green sea turtle at the Enchanted Islands. The SESV research initiative helps to solve scientific mysteries, as they help us to understand their behavior without human presence. Allowing us to comprehend the interaction, conduct, feeding habits and distribution of some species that until now were unknown. What we learn helps us protect them. This is an initiative from the TortugaNegraGalápagos project. The information contained in this video is part of a scientific project authorized by the Galapagos National Park. The equipment used, is exclusively for scientific purposes and

has no effect on the individuals studied, as they help us to understand their behavior without human presence. Also obtaining important conservation data such as: location, temperature and depth.

"HEALTHY SEAS: A JOURNEY FROM WASTE TO WEAR" FASHION PROJECT

Presenter/Organization: Anna Stamatiou, MEDASSET (Mediterranean Association to Save the Sea Turtles)

Description: In 2016, MEDASSET marked the first anniversary of its successful coordination in Greece of the European Initiative, "Healthy Seas: A Journey from Waste to Wear". The Initiative is a collaboration between several partner organisations that are removing abandoned fishing nets, also known as "ghost" nets, from our seas where, caught up on rocks and wrecks or drifting over the sea floor, they continue to pose a deadly threat to all kinds of marine creatures, sea turtles among them. The salvaged nets, along with other waste, are recycled to create premium quality ECONYL® yarn that is used in the manufacture of clothing, carpets, and other consumer products. MEDASSET collaborated with AKTO College of Art and Design to celebrate and raise awareness of the Healthy Seas Initiative. It challenged students to create outfits using fabric made from ECONYL® in a demonstration of the recycled yarn's potential. Our film starts with the event we held to celebrate the work of Healthy Seas and also that of the students. The concepts behind the Initiative are presented, such as the consequences of "ghost" fishing and of the benefits in terms of environmental improvements and job creation that can be derived from the implementation of a more circular business model. There is footage of divers reclaiming ghost nets and freeing turtles as well as students working on their designs and the finished outfits they made. Each of the creations used fabric woven from recycled ECONYL® yarn, while some of them included additional eco-friendly materials.

Dance Your Research

Presenter/Organization: Padraic O'Flaherty

Description: This video is submitted as Padraic O'Flaherty's entry in the 2017 International Sea Turtle Symposium Dance-Your-Research contest. Drawing on the truths about the connectedness of life and the healing power of such connections, an analogy is made between the role of science, and conservation biology in particular, and tango. As couples navigate a dance floor and grow in their awareness of themselves, each other and their environment, so too do conservation biologists grow in their understanding of sea turtles and work with relevant communities to conserve populations while developing economic opportunities and, ultimately, healing the world.

Link: https://youtu.be/XomsE4MMBYA

Presenter/Organization: Kiki Jenkins

Description: This dance depicts four factors for the successful invention and use of TEDs: the inventor will (1) engage in mental modeling, be an experienced (2) shrimper and (3) fabricator, and (4) influence high adoption of their TED locally. The dance has five sections: (1) turtle succumbs to threats, (2) beach-walker/ESA witnesses strandings, (3) factors 1-3 combine to create a TED, (4) local inventor gains more adopters than non-local inventors, and (5) the four factors collectively save a turtle. The dance used participatory techniques: dancers read and created movement about Jenkins (2010), thus finding connections between the research and themselves.

Link: https://www.youtube.com/watch?v=Px2XpQ6M4pM

Presenter/Organization: Zoey Best

Description: As oviparous species with no parental care, loggerhead sea turtles rely on the internal conditions of their nests for offspring survival. Seasonal environmental factors can influence these internal nest conditions, directly affecting reproductive success. This study examined seasonal environmental variables and their effects on nesting numbers, incubation conditions, and hatching success. 25 years of sea turtle nesting data from Broward County Florida were analyzed, and regression models were fitted to exemplify seasonal and temporal patterns. These models can be used to estimate the potential effects of climate change on sea turtle reproduction, and to predict future loggerhead population trends.

Link: https://www.youtube.com/watch?v=oWlp-zqtZLY&feature=youtu.be

Presenter/Organization: Karumbé

Description: Karumbé NGO works for the research and conservation of sea turtles in Uruguay. The organization counts with a rescue network, giving assistance to stranded turtles. These turtles are release after their rehabilitation. This is a special moment to share with the community. The event makes possible to explain our labor and general information about sea turtles and to create awareness about the conservation of the turtles and preservation of the seas. Before returning the turtle to the sea, all the attendants dance this song, which talks about the marine fauna of the Uruguayan sea. You dance and sing while listing some of our most common marine animals: YO SOY UN CHUCHO (manta-ray), UNA TONINA (dolphin), UNA AGUAVIVA (jellyfish), Y UN TIBURÓN (shark)… YO SOY UN LOBO (sea lion), UNA TORTUGA (sea turtle), UN PEZ ESPADA (swordfish), UN GAVIOTIN (tern)…BIS !!

Link: https://www.youtube.com/watch?v=1pIVlU7ZUVg (credits: Ruta Tortugera)

Social, Cultural, & Community Events

Social and Awards Ceremony
The Opening Social will be held at Lodge at the Lawn on Monday, 17 April, 7 pm – 9 pm. Prior to the Opening Social, a Student Mixer will be held in the same space starting at 6 pm. The Awards Ceremony will take place in the Valencia Ballroom beginning at 7 pm after which dinner will be served.

Speed Chatting with Turtle Experts
This fundraising event aims to provide a means for symposium newcomers and veterans alike to spend time chatting with a stellar collection of turtle enthusiasts and ISTS Symposium veterans. This event is intended to be the "ice-breaker" for getting to know people you've always wanted to meet but have never approached. Speed chatting takes place from 5:30 pm to 7 pm in Andalucia on Wednesday (19th). Speed chatters will ask for a $5 donation that will go toward student travel for the next symposium.

Video Night
The video night has been running for several years and has become a popular event at the symposium. Video night attracts a large crowd and it is always a fun evening with a variety of different multi-media presentations. Video night is from 8 pm to 11 pm on Tuesday (18th) in Marquis Ballroom.

Silent and Live Auction

Silent and Live Auction items should be brought to the Grand Ballroom room beginning Saturday (15th) . The Silent Auction will be open for viewers and bidders from 9 am to 5 pm on Monday (17th), 9 am to 5 pm on Tuesday (18th), and 9 am to 1:30 pm on Wednesday (19th). Bids for Silent Auction items will be received only until 1:30 pm sharp. So, be sure that your preferred items have your bid as the last and highest bid on the page – this means you win! The Live Auction will be held on Wednesday (19th) from 8 pm to 12 am in the Marquis Ballroom. The Live Auction evening is a casual and social event with lots of fun, cheer, and competition! Veteran bidders compete with fresh hands and try to outbid each other for a variety of donated collectibles. The Live Auction is a firmly entrenched fundraising tradition not to be missed. We encourage all delegates, sponsors, and exhibitors to donate items for the Silent and Live Auctions. Proceeds from both auctions contribute to the travel grants for the next symposium. Donated items are often rare treasures! We encourage people to visit the Silent Auction and to attend the Live Auction to bid on these valuable turtle trinkets!

ORAL AND POSTER SESSION DESCRIPTIONS

Anatomy, Physiology, & Health

This session includes research on all aspects of sea turtle form and function, and how these relate to the environment. Studies and reports fitting in the anatomy, physiology, and health session include anatomy, functional morphology, physiology, reproductive biology, embryonic development, physiological stress, toxicology, thermal biology/thermoregulation, osmoregulation, and their relationships to normal turtle health. Studies of abnormal health or treatments do not belong in this session. Priority for oral presentations will be given to those studies demonstrating clear scientific methodology, presenting innovative approaches, methods, technology, and/or analyses, and those studies yielding novel findings.

Rehabilitation & Veterinary Care

This session includes research on rehabilitation and veterinary care and on individual and population-wide health problems. Includes studies and reports on diseases, veterinary care, rehabilitation, and health assessment. Priority for oral presentations will be given to those studies demonstrating clear scientific methodology, presenting innovative approaches, methods, technology, and/or analysis, and those yielding novel findings.

Nesting Biology (Ecology, Behavior, & Reproductive Success)

This session will focus on nesting beaches, nesting females, nests, hatchlings, eggs, and closely related topics. Relevant subjects include assessments of nesting population size, modelling of population parameters, long-term monitoring of nesting trends, forecasting population change, behavior of turtles on nesting beaches, hatching/emergence success and hatchling production, sea-finding behavior, environmental impacts on egg viability or nesting, newly discovered or newly colonized nesting areas, and related topics. Reports of nesting activity for short-term periods (<10 years) may be included in the poster session; studies revealing long-term nesting trends may be suitable for oral presentation if they reveal lessons relevant to other geographic areas. Priority for oral presentations will be given to studies that have a clear scientific methodology, report new findings, and/or involve innovative methods, technology or analysis.

In-Water Biology (Behavior, Ecology, Migration, Telemetry, & Foraging)

After entering the ocean as hatchlings, sea turtles do not leave the sea again except to nest (or occasionally to bask). This session broadly encompasses the biology of sea turtles in the ocean. It includes research on turtles of all life-history stages, with the goal of better understanding the biology and ecology of turtles in their underwater habitats. Suitable topics include behavioral or observational studies related to migration, diving, foraging, or navigation, as well as sightings, surveys and monitoring of turtles at sea (e.g., in developmental habitats or foraging areas), conservation status evaluations, and the structure and dynamics of populations, subpopulations, and metapopulations. Other topics include telemetry and movements, patterns of resource use and residency, mating behavior and social interactions, feeding behavior and diet composition, the ecological role turtles play in their diverse habitats, and the implications of habitat condition on the health and sustainability of turtles. Priority for oral presentations will be given to those works developed under a scientific method approach and those reporting new or innovative findings.

Population Biology & Monitoring (Status, Modeling, Demography, Genetics, Nesting Trends, & In-Water Trends)

This session focuses on sea turtle population assessments and related topics. Specific topics include: population demography (i.e. survival probabilities, growth rates and reproductive rates); abundance and trends; population structure and population connectivity; population genetics (e.g., mixed stock analysis); management unit/population segment definitions. Studies from both nesting and foraging habitats are welcomed, as are modelling approaches to population biology in which mathematical or simulation models are used to elucidate marine turtle population parameters and vital rates. Priority for oral sessions will be given to presentations that involve novel, integrative approaches to defining demography and population structure, as well as reports involving long-term monitoring programs. Short-term assessments of nesting populations and descriptive studies should be submitted as poster presentations.

Fisheries & Threats

This session focuses on the evaluation of natural and anthropogenic threats that degrade the condition of critical sea turtle habitats, or which increase the risk of mortality and major population declines of sea turtles on any geographic scale. Topics include: fisheries bycatch, characterization of fishing gear and fishing effort, directed take, strandings due to any factor (including cold-stunning), impact of degradation of nesting and feeding habitats, impacts of urban development in coastal areas, and emerging threats from climate change, among others. Presentations may also include evaluation of potential impacts of either known or newly discovered threats, as well as proposed or actual measures taken to reduce risks to turtle populations. Priority for oral presentations will be given to those studies showing a clear scientific method approach, and those presenting innovations in their approaches, technology and/or analysis.

Conservation, Management, & Policy

This session will highlight work on economic, legal, policy, and management aspects of sea turtles and their conservation. Topics include studies and reports that address issues of legislative support and enforcement, policies and programs that safeguard sea turtles and their habitats, management issues related to sea turtle monitoring and conservation, and related matters. This session will also include reports on the implementation, results, and impact of initiatives and international agreements pertaining to sea turtle protection. Priority for oral presentations will be given to presentations that meet several of the following criteria: includes new data and/or a new perspective; presents novel approaches to sea turtle conservation, management, and/or public policy; highlights a global geographic area that has previously been under-reported; includes robust evaluation of implementation, methodology and policy; describes use and application of new tools in management initiatives that result in successful conservation outcomes.

Education, Outreach, & Advocacy

Sea turtles cannot be protected or conserved unless people take an interest in their continued survival. This session focuses on innovative educational methods for raising awareness of sea turtles and promoting their conservation in different parts of the world, as well as efforts to develop and enhance advocacy efforts on behalf of sea turtles at any level of community or government. Topics include a broad range of approaches to educational outreach and to advocacy, as well as strategies for influencing decision-makers and efforts to convert potential adversaries (e.g., fishermen or egg poachers) into allies. Priority for oral presentations will be given to those who highlight innovative approaches, methods, results, and lessons that may be widely applicable to outreach and advocacy efforts in many regions worldwide.

Social, Economic, & Cultural Studies

Sea turtles play a crucial role not only in marine ecosystems, but also in human societies. This session includes presentations that broadly explore the human dimension of sea turtles and the importance of turtles in diverse cultures and societies around the world. Some presentations focus on research projects, but others highlight initiatives related to the conservation of sea turtles and their habitats, or efforts to understand local attitudes toward sea turtles and conservation. Topics include but are not limited to: social science and/or anthropological research; discussions of cultural considerations related to conservation and management; sea turtles in local folklore, mythology, and culture; examinations of conflict and conflict resolution; studies of information and/or technology transfer between local peoples and other experts. Priority in oral presentations will be given to authors who provide clear indications of social science or other recognized approaches in their abstracts, those discussing under-reported geographic regions, and those with compelling case studies that may hold global lessons.

Special Theme: Citizen Science

The special session “Climate Change” consisted of oral presentations that highlighted the consequences that sea turtles currently face and will face in the future with respect to ongoing climate change.

Special Theme: Climate Change

The special session “Citizen Science” consisted of oral presentations that showcased how the general public can get involved with and assist sea turtle conservation.

ABSTRACTS

Anatomy, Physiology and Health

MHC CLASS I AND ITS INFLUENCE ON SUSCEPTIBILITY TO FIBROPAPILLOMATOSIS IN GREEN TURTLES (*CHELONIA MYDAS*) AND LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*)

Elizabeth Abney[1]

[1]*University of Central Florida, Orlando, Florida, USA*

Green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles are the two primary species of turtle found in Florida's coastal waters. In both species, the Florida populations are listed as threatened under the U.S. Endangered Species Act. Both species were classified as endangered by the IUCN until 2015 when the loggerheads were reclassified as vulnerable. Although conservation efforts have been moderately successful in protecting and assisting the recovery of marine turtles, sea turtle mortality due to diseases, including viral diseases, is an ongoing concern. Fibropapillomatosis, historically associated with cheloniid fibropapilloma-associated herpesvirus (CFPHV) is found in all species of marine turtles and presents itself as epithelial fibropapillomas and internal fibromas. Tumors prove to be deadly when they begin to interfere with a turtle's ability to function efficiently. Understanding what factors influence the susceptibility of marine turtles to this disease is a necessary step towards effective conservation. One factor involved in disease susceptibility in all vertebrates is the Major Histocompatibility Complex (MHC). MHC is involved in many functions, including the control of specific immune responses such as self/nonself recognition and antigen presentation to T-lymphocytes. Due to its role in disease resistance and susceptibility, MHC is increasingly studied in association with disease states in order to study its association with infection. Here, we assess the influence of MHC class I exon I variation on disease carriage of CFPHV in two species of marine turtle. Genomic DNA was extracted from green turtle and loggerhead skin samples. Quantitative PCR was used to determine whether individuals were infected with CFPHV. Amplicon genotyping will be applied to amplify the specific area of interest for sequencing. We will present the exon 1 sequencing of MHC class 1 found in turtles affected by CFPHV at ISTS 37. Understanding the marine turtle immune response to herpesviruses is an important step in finding solutions to protect the species from extinction. A comprehensive knowledge of the viruses which affect marine turtles and how human factors influence them can prove useful in making responsible legislative decisions in the future to protect marine turtles.

FIBROPAPILLOMATOSIS IN AFRICA –DATA AVAILABLE FOR FP IN AFRICA AND KNOWLEDGE GAPS – TOWARD A GLOBAL STRATEGY FOR FP EVALUATION IN AFRICA

Alexandre Girard[1,2]

[1]*Rastoma, Network of the Sea Turtle Conservation Actors in Central Africa*
[2]*Laboratoire Ecologie Systématique et Evolution (ESE), Université Paris Sud, Orsay*

Ecology of disease is relatively new concern for marine conservation programs. In this context, marine turtle conservation program could serve as textbook case given the long-term studies about emergence and propagation of fibropapillomatosis (FP) infection. It has been described in all oceanic basin but some

regions, including Africa, are still under documented. A literature survey has been done to record any FP description along the Atlantic and Indian Ocean African coasts. Then interview with different teams working along these coasts permit to enrich the database of FP prevalence. In West Africa, the most northerly FP cases have been observed in Mauritania. Cases were recorded in stranded green turtle in Banc d'Arguin from 2009 and FP rate seems to have increased sharply recently (prevalence estimate 20% in 2015). In addition, anecdotal observations of FP were recorded in the Northern part of the Senegal (Saloum Delta), Gambia and Guinea Bissau (Bijagos and Continental Guinea Bissau). In Nigeria, FP-like lesions have not been observed from green juveniles. In the recent years, the most comprehensively documented area for FP in Africa has been Central Africa where three studies provide reliable FP rates. High FP rates (34.04%) were recorded in Principe (Sao Tome & Principe). In Corisco bay, a feeding ground at the border between North Gabon and South Equatorial Guinea, a survey (1998–2006) revealed an average FP prevalence of 16.98%. In the Republic of Congo, the current FP rate at Loango Bay is approximately 10%. The 2008-14 FP rate trend in Congo shows that a 20% peak occurred in 2009. The global 7-year trend demonstrates a slight decrease over the years. No case of FP has been observed in the Democratic Republic of Congo despite a monitoring of bycatch and stranding over 6 years (2009-2015). There is no data on FP available to our knowledge in Angola and South Africa. Regarding the Indian Ocean Coast of Africa (East Africa), there is no available data to our knowledge about FP in Mozambique. In the Mozambique Channel, FP has been well documented in Barren Islands on the western coast of Madagascar, where FP rates monitored in 2010-2012 ranged from 9 to 13%. Anecdotal FP cases were recorded in Comoros Island, in Tanzania and in Kenya. While FP is present at least at low level in nearly all sites along the coastline of western and eastern Africa. Prevalence and trends of FP is not currently efficiently monitored in most of the sites and impact of FP on sea turtle population in Africa remains unclear. Harmonized monitoring program targeted for FP are needed to characterize FP prevalence trends on green turtle feeding grounds along western and eastern African coasts. The determination of causes and mechanism leading to the FP expression could be solved from a meta-analysis of these data. Finally, regional strategies should address explicitly this threat.

UNUSUAL SEXUAL DIMORPHISM AND SMALL ADULT SIZE FOR OLIVE RIDLEY SEA TURTLE ARE LINKED TO SIZE AND MASS DEVELOPMENTAL CONSTRAINT*

Alexandre Girard[1,2], Nathalie Breheret[3], Bal Gaëlle[3], Jean-Gabriel Mavoungou[3], Félix Tchibinda[3], Fils Makaya[3], Marc Girondot[2]

[1]Rastoma, Network of the Sea Turtle Conservation Actors in Central Africa (Regional Office Dizangue Cameroun)
[2]Ecologie Systématique Evolution, Univ. Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay 91400 Orsay, France
[3]Association Renatura Congo BP 414, Pointe Noire, Republic of the Congo

The differences between both sexes encompass the characters directly involved in reproduction as well as other characters known as sexual dimorphism (SD). Sexual size dimorphism (SSD) is a form of SD in which the two sexes do not have an equal adult size. Darwin (1876) proposed that the evolution of sexual dimorphism might result from sexual selection pressures operating on a single sex, such as male combats and female choice. Such a mechanism might contribute to SSD when the mating process involves male-to-male combats with larger males being more prone to win, then larger males have higher reproductive success. Natural selection would lead to larger female body-size when it was positively correlated with fecundity. In sea turtles, the most common SSD is a larger female pattern, and as expected, a positive relationship between adult body size and clutch size was found in the five species with sufficient data to be tested (Van Buskirk & Crowder 1994). SSD observation linked with life-history correlation is a unique

way to decipher strategies used by individuals that are very rarely encountered. Marine turtles are challenging for SSD, because only females are observed on beaches, with a strong dissymmetry in male versus female observations being the rule. The situation in the Republic of the Congo is exceptional because male and female data from the same area have been collected from both a sea turtle bycatch program and monitoring of nesting population in the same area permit to establish SSD in olive ridley turtles (*Lepidochelys olivacea*). The data obtained from these surveys give access to the body size of male and female olive ridleys (*Lepidochelys olivacea*). Curved carapace length (CCL) in male and female olive ridleys reveals sexual size dimorphism (SSD), with males being larger than females. This large male SSD contrasts with the female-biased or absence of SSD commonly observed in sea turtles. Phylogenetic information shows that the absence of SSD is the ancestral state in marine turtles. The ultimate and proximate mechanisms potentially at play are discussed and tested where possible. One of the main drivers of the smaller female SSD could be egg production. We show that egg production in olive ridleys in the Congo is optimal for intermediate female CCL. When females are longer, egg production decreases, probably because of constrained three-dimensional volume. This counterintuitive relationship between CCL and egg production could be the driving force behind the unusual evolution of the larger male SSD in olive ridley turtles, and ultimately it could drive the small size of this species as compared to other marine turtles.

EGGSHELL POROSITY AND WATER VAPOR CONDUCTANCE ON WESTERN POND TURTLE, *EMYS MARMORATA* AND OLIVE RIDLEY, *LEPIDOCHELYS OLIVACEA*

Gabriela Alfaro[1], Nicholas Geist[1]

[1]*Sonoma State University*

Gas and moisture exchange across the shell membrane is limited by the diffusive properties of gases, and the porosity of an eggshell. The regulation of such gases can be quantified as a porosity value or experimentally determined by testing water vapor conductance. Porosity value and water vapor conductance, along with nesting behavior, could predict hatching success of an embryo. The aim of this study was to analyze eggshell porosity and water vapor conductance in the western pond turtle, *Emys marmorat*a, and the olive ridley sea turtle, *Lepidochelys olivacea*, and its relationship to nesting behavior. Eggshells, dated 2000-2015, were analyzed under the Scanning Electron Microscope (SEM) and measurements were scored. We calculated porosity value relative to egg mass by using a series of calculations, based on previous research. Water vapor conductance was calculated as the water lost to the environment over a period of three days. Further comparison of porosity values can be used to predict the outcome of oviparous species and their relationship to environmental changes, since toxins and elevated temperatures might have a detrimental impact on the development of embryos. Modeling ideal environmental conditions to incubate eggs is imperative to implement conservation measurements and ensure the survival of threatened or endangered species such as *E. marmorata* and *L. olivacea*.

ANALYSIS ON THE ADAPTATIONS OF THE DIVING CAPACITY IN ONE SPECIE OF SEA TURTLES, *LEPIDOCHELYS OLIVACEA*, COMMONLY KNOWN AS OLIVE RIDLEY

Gabriela Alfaro[1], Martha Harfush-Meléndez[1], Daniel Crocker[1]

[1]*Sonoma State University*

Sea turtles are air-breathing divers that have been documented to dive on inhalation. Despite the importance of the diving capacity for a sea turtle, allometric data on their diving ability is very limited, to the sole documentation of lung size relative to mass. For a more complete understanding on their diving physiology, previous studies have suggested the analysis of blood and tissue oxygen storages to investigate the possibility of a trade off between lung size and blood/tissue oxygen storages. The aim of this study was to create baseline parameters of the diving physiological adaptations that enable sea turtles to stay underwater for long periods of time, which is currently lacking in the scientific literature. To test this hypothesis, *Lepidochelys olivacea*, (wild females, captive adults and captive juveniles) were used to collect blood and tissue samples to establish plasma volume, hemoglobin, hematocrit, hormones, metabolites, and iron status. Our preliminary results provide a starting point into subsequent analysis and can be used to compare the same physiological adaptations in different species of sea turtles and even to mammals, which breathe on exhalation. This study also extends our knowledge into the diving adaptations that enable sea turtles to potentially increase foraging time, enhance migration, mating, and reduce being preyed upon by limiting their surface time.

THERMAL SENSITIVITY AND CRITICAL THERMAL MAXIMA OF OLIVE RIDLEY SEA TURTLE EMBRYOS STUDIED BY CARDIAC PERFORMANCE

Julieta Alvarez-Servín[1], F. Alberto Abreu-Grobois[2]

[1]*Posgrado en Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, México.* [2]*Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Mazatlán Sinaloa 82040, México*

The most dramatic impacts of climate change on sea turtles will most likely occur on the embryonic stage that has a narrow viable temperature range (24 to 34°C). However, these limits are based on experiments with constant temperatures over the entire incubation period that could bias predictions for impacts by acute heat stress lasting hours or days. We monitored cardiac rates in olive ridley embryos under acute heat stress to study physiological responses to thermal stress and identify upper thermal tolerances for embryos incubated at two constant temperatures (28° and 32°C) and sampled during the midpoints of the first, middle and last third of the incubation period. The thermal stress test was a continuous temperature increase from prior temperature (1.5° C/hour) while monitoring heart rate. All embryos exhibited a similar pattern of thermal sensitivity: steadily rising heart rates from basal values (approx. 85 or 100 BPM, for 28 and 32°C incubations resp.) reflecting an ability to respond physiologically to acute and changing temperature stress by increasing metabolic rate. For embryos incubated at 32°C, maximum heart rates (170-180 BPM) were registered for temperatures of 40-43°C after 7 hours. Subsequently heart rates dropped sharply between 43-45°C. No embryos recovered from cardiac arrest, indicating upper lethal temperature (ULT) of over 45°C. Embryos incubated at 28° had a significantly lower basal and maximal (160 BPM) heart rates, but similar ULT indicating that higher incubation temperatures facilitate thermal acclimation. While embryos from the first third of the incubation exhibited significantly steeper heart increases, lower maximal heart rates

(160BPM) and at lower temperature (37°C) than the other two periods, embryos from the middle third consistently displayed response curves slightly lower than those from the last third. We suggest our results identify the greatest vulnerability to thermal stress in the initial third of the incubation and a much greater resistance from the middle of the incubation onwards that mirror results from field experiments. Lineal and general additive mixed modelling indicated a significant effect of the different nests on the variability of results. The very high upper lethal temperatures we found, while surprising given our current knowledge on thermal tolerance in sea turtle embryos, suggests that realistic evaluations of thermal tolerance in sea turtles embryos needs to consider acute conditions and much higher ranges. The experimental system we have developed is relatively simple to construct yet provides repeatable and quantitative results relatively quickly and at low costs. It can readily be expanded for more complex evaluations such as comparative studies between and within species, as well as assaying mortality rates in combinations of temperature and exposure times for more comprehensive evaluations.

PREVALENCE AND MOLECULAR CHARACTERIZATION OF CHELONID HERPESVIRUS 5 (ChHV5) IN GREEN TURTLES (*CHELONIA MYDAS*) WITH AND WITH FIBROPAPILLOMATOSIS IN AREAS OF BRAZILIAN ATLANTIC COAST*

Marco Aurélio Gattamorta[1,2,3], Sheila Oliveira de Souza Silva[4], Sueli Akemi Taniwaki[4], Ana Cristina Vigliar Bondioli[5], Juliana Jordão[5], Fabiola Eloísa Setim Prioste[1], Silmara Rossi[1,3], Paulo Eduardo Brandão[4], Eliana Reiko Matushima[1,6]

[1]Grupo de Pesquisa sobre Fibropapilomatose em Tartarugas Marinhas - Universidade de São Paulo - Brazil
[2]Faculdades Metropolitanas Unidas (FMU), Brazil
[3]Fundação de Estudos e Pesquisas Aquãticas (FUNDESPA), Brazil
[4]Laboratório de Biologia Molecular Aplicada e Sorologia, Departamento de Medicina Veterinária Preventiva e Saúde Animal. Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[5]Universidade de São Paulo, Brazil
[6]Laboratório de Patologia Comparada de Animais Selvagens Departamento de Patologia Faculdade de Medicina Veterinária e Zootecnia Universidade de São Paulo, Brazil
[4]Faculdades Metropolitanas Unidas - FMU, Brazil

Chelonid herpesvirus 5 (ChHV5) has been indicated as the primary infectious agent of fibropapillomatosis (FP) in sea turtles, and the disease has a higher prevalence in green sea turtles (*Chelonia mydas*). The herpesvirus can also establish latent infections without clinical manifestation of the disease, but studies evaluating the feature of these agents are quite recent in sea turtles. Skin and tumor samples of 136 green sea turtles were collected in a mixed area (Fernando de Noronha – PE) and two feeding areas (Vitória – ES and Ubatuba – SP) in order to determine the prevalence of ChHV5 in individuals with and without FP. In addition, molecular characterization of the virus and analysis of the co-evolutionary relationship between viral variants and reproductive origin of *C. mydas* (characterized by mtDNA) were carried out. The prevalence of ChHV5 in FP negative specimens was 9.56% rising to 45.58% when also considering animals with FP. The FP and the presence of the agent in Fernando de Noronha – PE were not detected, whereas the prevalence of the virus was 57.14% in Vitória – ES and 74.51% in Ubatuba-SP. The characterization of partial sequences of DNA polymerase of ChHV5 allowed the identification of two new viral variants in the coast of Brazil, one of which (Var. 7) was the predominant variant in Vitória – ES and Ubatuba – SP, and previously identified in secretions and nerve tissues, while Var. 8 was found only in Vitória – ES. It was not possible to observe co-evolution of viral variants and haplotypes of *C. mydas*, because infection by Var. 7 was detected in CM-A3, CM-A5, CM-A6, CM-A8 and CM-A9 individuals. This result indicates

that the mtDNA control region cannot be used to evaluate co-evolutionary relationships among virus variants and infected animals. We were unable to find viral previously identified variants in Vitória – ES and Ubatuba – SP, which may indicate that these variants have been replaced by ones with more infectivity. High similarity was also observed between the variants identified in this study and those previously found in Brazil with ChHV5 sequences of Puerto Rico and Gulf of Guinea. The ChHV5 high substitution rates and the replacement of variants detected in this study indicate the need for long-term ecological and epidemiological studies.

COMPARATIVE ANALYSIS OF CONGENITAL MALFORMATION RATES BETWEEN TWO OLIVE RIDLEY NESTING COLONIES FROM MEXICAN PACIFIC COAST*

Annelisse Bárcenas-Ibarra[1], Horacio de la Cueva[2], Julian M. Zepeda-Gayol[1], Michelle E. Dorantes-Palacios[3], Miguel Á. Coyote-Tabaco[4]

[1]BIOCI A.C.
[2]CICESE
[3]ASUPMATOMA A.C.
[4]Universidad Autónoma Metropolitana

All alterations during early development, caused by either genetic or environmental factors, can drastically affect embryonic processes or generate congenital malformations. Sea turtle congenital malformations are relatively rare, indicating negative changes in their biology. While studies focusing on the conservation and protection of sea turtles have risen in recent years, only a few address malformations. Congenital malformation frequency for embryos and hatchlings of sea turtles ranges from 0.2% to 2%. A recent study of congenital malformation rates of three sea turtle species breeding on Mexican beaches has shown that the highest malformation frequency rates are occurring in the olive ridley (*Lepidochelys olivacea*). However, these results may be strongly affected by management strategies. We present results from detailed quantitative analyses of congenital malformations based on external anatomy observations in hatcheries from two olive ridley nesting beaches on the north-western Mexican coast involving three different management strategies. We examined 597 (hatchery) and 41 (in situ) nests at San Cristobal beach during 2015 nesting season. For El Verde beach 49 (Styrofoam boxes) and 170 (Styrofoam boxes) and 39 (hatchery) nests during the 2011 and 2012 nesting seasons, respectively, were examined. Data recorded for each nest included: number of eggs, hatchlings (alive and dead), and eggs with or without embryonic development. Hatching and mortality levels were compared for nests with and without congenital malformations. Malformation frequency was evaluated with indices of (i) prevalence, as the proportion of eggs and nests with at least one malformation, and (ii) severity, as the number of malformations per organism and nest. Overall, El Verde Beach showed significantly higher mortality rates (including dead hatchlings inside the nest, eggs with obvious embryonic development, and eggs without obvious embryonic development), and lower hatching success than those observed at San Cristobal Beach. In both beaches, mortality in nests containing malformed organisms was significantly higher than in nests without malformations and therefore hatching success was significantly lower in nests with congenital malformations than those without. Comparison between beaches showed that mortality and hatching levels were significantly higher and lower, respectively, in nests with congenital malformations for El Verde Beach than from San Cristobal Beach. Prevalence was significantly higher in nests from El Verde Beach than those from San Cristobal Beach. No significant differences in severity were observed between beaches. Olive ridley nests from El Verde Beach seem more prone to the occurrence of congenital malformations than those from San Cristobal Beach. These differences could suggest an effect from intrinsic incubation factors in these nests perhaps associated with the nesting female's health condition at

each nesting beach. Whether the observed malformation levels are normal or represent a health problem cannot be currently determined without long-term assessments.

COMPARING PERSISTENT ORGANIC POLLUTANTS AND TRACE METALS IN GREEN SEA TURTLES INHABITING TWO URBANIZED HABITATS IN SOUTHERN CALIFORNIA*

Arthur Barraza[1], Lisa Komoroske[2], Varenka Lorenzi[3], Dan Lawson[4], Tomoharu Eguchi[2], Jeffrey A. Seminoff[2], Robin LeRoux[2], Christopher G. Lowe[1]

[1]Department of Biological Sciences, California State University, Long Beach.
[2]Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration.
[3]Institute for Integrated Research on Materials, Environment, and Society, California State University, Long Beach.
[4]Protected Resources Division, West Coast Regional Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration.

Persistent organic pollutants (POP) and trace metal contamination are associated with deleterious health effects on organisms living in urbanized coastal regions. Two foraging aggregations of east Pacific green sea turtles (Chelonia mydas) inhabiting the Long Beach (LB) and San Diego (SD) areas exhibit year-round presence and strong site fidelity. New individuals recruit to these aggregations annually; and green turtle strandings occur along the coast throughout the year. Given the prevalent use of these areas as foraging habitat for green sea turtles in the eastern Pacific, characterizing the contaminant loads of these two aggregations of green sea turtles is important towards understanding possible negative effects of anthropogenic contaminants. To calibrate methods for POP and trace metal contamination, green sea turtles that have stranded in the Los Angeles and San Diego areas had their liver, heart, kidney, muscle, and fat tissue extracted and analyzed for POP and trace metal contamination using gas chromatography mass spectrometry (GCMS) and inductively coupled plasma mass spectrometry (ICPMS). Preliminary results on stranded green sea turtles indicate undetectable (MDL 1 – 0.5 ng/g) to moderate amounts of POP contamination (123.00 – 9.51 ng/g wet mass total POPs in fat, heart and muscle tissue) in both aggregations of green sea turtles. Comparatively, preliminary results indicate possible differences in trace metal contamination between green sea turtles in San Diego and Long Beach; however, there are too few individuals to make a statistical comparison. Stranded individuals from SD (n = 6 turtles) had lower total trace metal content (276.24 – 842.97 µg/g wet mass, range; 402.76 ± 106.11 µg/ wet mass, mean ± SE) than the LB individual (1111.55 µg/g wet mass, n = 1 turtle) in their tissues. The stranded individual from LB had high amounts of cadmium contamination (221.49 µg/g wet mass) in kidney tissue compared with another stranded individual from SD (53.26 µg/g wet mass). While samples from stranded green sea turtles were used to calibrate methodology, 37 live green sea turtles from the Seal Beach National Wildlife Refuge (n = 14 turtles) and San Diego Bay (n = 23 turtles), two important foraging habitats, were captured, measured and had blood and scute samples taken. POP contamination will be determined using blood plasma with a modified soxhlet extraction using GCMS. Trace metal contamination will be determined using red blood cells and scute samples with acid digestion and ICPMS. While analysis of live green sea turtle samples is pending, blood and scute samples will be used to corroborate the preliminary results found in stranded green sea turtle samples. Particularly, to assess the level of POP contamination in these two foraging aggregations, and to assess whether there are differences in trace metal contamination between green sea turtles in both locations.

TOWARDS A MORE EFFICIENT USE OF ANTIBIOTICS AT SEA TURTLES CARE CENTER, IN REUNION ISLAND

Mathieu Barret[1], Claire Jean[1], Fabienne Cadet[2], Tiphaine Moulin[2], Francis Schneider[2], Stéphane Ciccione[1]

[1]*Kelonia*
[2]*Vetoru*

Since 2006, bactericidal treatments at Kelonia's care center have progressed with the aim of avoiding and minimizing antibiotic resistance. Kelonia took in charge four of the five species that inhabit the Western Indian Ocean (*Caretta caretta* N= 173; *Chelonia mydas* N=39, *Lepidochelys olivacea* N= 28, *Eretmochelys imbricata* N=25). The main causes of arrivals were: by-catch, ghost nets, boat collision, sick, weakened and newborn hatchling. As for dead turtles a necropsy was systematically performed. Since 2008, bacteriological analyses were run for every turtle from samples of shells, infected wounds, feces, blood or organs for died turtles (624 samples in total). Additional tests were run as routine analysis to monitor general health. Every year an assessment of analysis results was made to monitor bacteria species and the evolution of their sensitivity to antibiotics. More than 20 bacteria species were found with predominance for *Citrobacter* spp. (17%), *Enterobacter* spp. (8%) and *Klebsiella* spp. (7%). We also observed, over the years, the emergence of new bacteria never found before at Kelonia, such as *Morganella morganii*, *Acinetobacter baumanii* and *Aeromonas* spp. Results also revealed that sea turtle species are differently affected. As an example, some of *Lepidochelys olivacea*, positively tested for *Morganella morganii*, contracted an osteolysis disease. Hopefully, the first results showed that less than 10% of these tests came back positive for the most pathogenic strains of bacteria. It is well documented that bacteria may develop any kind of resistance to antibiotic drugs and that the use of these drugs should follow a strict protocol to ensure the product's efficiency and create the least resistance possible. The monitoring set up over the years has allowed inferring the pathogenicity of bacteria species and strains, the real efficiency of antibiotic treatments and trends in antibiotic resistance in bacteria thanks to bacteria/antibiogram tests and results. The prophylaxis set in place, including the use of antibiotics, has allowed a fast recovery for the majority of marine turtles. For the more difficult cases, more accurate treatments were required to target the bacteria responsible for the poor health status. Kelonia's care center works to associate diseases to bacteria and these preliminary results confirmed the importance of using antibiotics only when needed and following a clearly defined protocol. Also, they led us to experiment other substances that killed bacteria without creating any resistance. Finally, as no safe and effective antibacterial dosages specific to sea turtles exist, those results contribute to improving the prophylaxis protocol with the aim of better rehabilitation success for marine turtles.

A REVIEW OF FIBROPAPILLOMATOSIS IN THE BAHAMAS*

Annabelle Brooks[1], Alan B. Bolten[2], Mariana M. P. B. Fuentes[3], Stephen Connett[4], Barbara Crouchley[4], Meagan Gary[1], Rachel Miller[5], Ninive Espinoza[5], Elizabeth R. Whitman[1], Anthony Gillis[3], Karen A. Bjorndal[2]

[1]*Cape Eleuthera Institute*
[2]*University of Florida*
[3]*Florida State University*
[4]*Family Island Research and Education*
[5]*James Cook University*

Fibropapillomatosis disease (FP) is a debilitating disease that afflicts sea turtles in the wild, first observed in the 1800s but not widely reported until the 1980s. The disease presents itself as external and internal tumors, most commonly in immature turtles at coastal foraging grounds. The cause of the disease is yet to be confirmed, but it is believed that environmental pollution may play a role. FP primarily affects both green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles but all species have been reported to have been afflicted. The disease can result in mortality but there is also evidence of recovery through natural processes. The 2015 International Summit on Fibropapillomatosis called for continued monitoring to detect changes in occurrence, distribution and severity of the disease. Long term data are rare so here we have pooled data from 5 research projects that have monitored sea turtles across the Bahamian archipelago since 1969. From 8822 captures and recaptures we illustrate the spatial occurrence of FP (n=133) in 13 islands throughout the Bahamian archipelago. Importantly, localities where no FP has been reported in captured turtles are also identified. FP was first observed in Crooked Acklins in 1992 and Grand Bahama, then in Andros in 2006. The highest incidence of FP however has been between 2010 and the present. Afflicted individuals have been green turtles apart from one loggerhead and one hawksbill turtle, with a mean size of 48.8cm straight carapace length and mean mass of 15.41kg. The severity of tumors were predominantly (67%) mildly afflicted, and a small proportion moderately (18%) and severely (13%) afflicted. 39% of tumors were located around the eye area, 28% around the anterior flippers, 20% around the posterior flippers, 10% around the neck and the remaining 3% on the plastron. Abaco, Crooked Island, Great Exuma and Bimini islands showed the highest occurrence of FP with 16 – 30% of the captured sea turtles afflicted. Eleuthera island has the lowest occurrence (under 1%), limited to just the north end of the island, and Inagua and Conception have had no FP in over 40 years and 30 years of monitoring respectively. Many of the infected habitats documented here are far removed from sources of man-made pollution and next steps are to continue monitoring for the disease and to also explore associations between FP, both environmental and ecological, to determine the cause of this threat.

REFLECTION ON THE 2016 LARGE-SCALE COLD STUNNING EVENT IN NORTH CAROLINA

Emily F. Christiansen[1], Craig A. Harms[2], Matthew H. Godfrey[2,3], Sarah A. Finn[3]

[1]North Carolina Aquariums, Raleigh, North Carolina 27604 USA
[2]Department of Clinical Sciences and Environmental Medicine Consortium, College of Veterinary Medicine, Center for Marine Sciences and Technology, North Carolina State University, Morehead City, North Carolina 28557 USA
[3]NC Sea Turtle Project, North Carolina Wildlife Resources Commission, Division of Wildlife Management Raleigh North Carolina 27699 USA

Following an unusually temperate fall and early winter, the Atlantic coast of North Carolina experienced a sudden and drastic decrease of estuarine water temperatures in early January 2016. This resulted in a massive cold stunning event affecting over 1900 sea turtles over a period of three weeks, predominantly juvenile green sea turtles (*Chelonia mydas*) in the 2.0-3.5 kg body weight class. The estuarine sounds of the Outer Banks are prolific foraging grounds for juvenile sea turtles, and their relatively shallow water and few inlets leading to open ocean result in prime conditions for cold stunning events. Despite having the second-longest Atlantic coastline in the United States, North Carolina possesses modest resources to respond to marine animal stranding events, and only two dedicated sea turtle rehabilitation facilities, the Sea Turtle Assistance and Rehabilitation (STAR) Center at the NC Aquarium on Roanoke Island, and the Karen Beasley Sea Turtle Rescue and Rehabilitation Center (KBSTRRC), although the other two North Carolina Aquarium facilities frequently serve as overflow short-term holding facilities during sea turtle cold stun events. In contrast to mass cold stunning events in more northern Atlantic states, sea turtles affected in the Southeastern United States, particularly in the early stages of an event, are consistently in good body condition with minimal physiological derangements and few indications of systemic illness. This allows for rapid triage and release of individuals meeting criteria for a high likelihood of survival upon release: adequate body condition, appropriate attitude, absence of appreciable visual deficits or physical injuries, and normal swimming and diving behavior. Overall mortality was low in the first week of the event, but increased substantially as the month progressed. The majority of animals fell into two distinct categories: those that died either during transport to a triage facility or within the first 12-24 hours, despite basic supportive care, and those that either promptly regained appropriate attitude and activity during rewarming, or that responded rapidly to a standard course of antibiotics for wounds or respiratory abnormalities and were candidates for release within a few weeks. A minority required more intensive fluid therapy, medications, and prolonged care. By the end of January, over 900 affected turtles had been released into warmer waters off the coast of Florida or offshore of North Carolina adjacent to the Gulf Stream current. Of those turtles, over 400 were released directly upon rewarming, when transport was available; most spent a few days to weeks in triage and rehabilitation facilities. Approximately 150 turtles were left in the care of facilities throughout North Carolina and neighboring states, including several aquaria that historically have not participated in sea turtle rehabilitation. In total, 1043 turtles have been released from the 2016 mass cold stunning event.

CARAPACE ASYMMETRY: A POSSIBLE BIOMARKER FOR METAL AND METALLOIDS ACCUMULATION IN ADULT OLIVE RIDLEYS MARINE TURTLES?

Adriana A. Cortés-Gómez[1], Diego Romero[2], Marc Girondot[1]

[1]Université Paris-Sud AgroParis Tech CNRS Université Paris Sacle
[2]Universidad de Murcia

The Olive Ridley marine turtle (*Lepidochelys olivacea*) is characterized by remarkable morphological variability in the number and shape of scutes, the origin of which is thought to be based on a permissive genetic background. The influence of pollutants on developmental instability and one of its consequences, the asymmetry of individuals, has been demonstrated in several species but the reverse link has never been explored: is it possible that asymmetry at adult stage is an indicator of the contamination of individuals? We developed an index to quantify developmental instability (DIx) based on the number and relative size of costal carapace scutes. We then explored the link between this DIx and metal and metalloid concentrations of various tissues and egg components of stranded dead Olive Ridley females from the Southern Pacific coast of Mexico. Using a model selection based on the Akaike Information Criterion, we found a positive relationship between DIx and metal concentration in some tissues and a negative relationship with some egg components. Different hypotheses can be proposed to explain these statistically significant relationships: contamination is either a cause or consequence of the observed asymmetry, or both are linked to a third unknown factor. Then the relationship between adult contamination and DIx could reflect direct or indirect (i) disruption of metal elimination in the adult stage dependent on embryonic perturbation determining DIx or (ii) difference on absorption of metal dependent on DIx status.

DETECTION OF CHELONID HERPESVIRUS 5 (ChHV5) AND NECROPSY FINDINGS: PRELIMINARY RESULTS IN LUNG OF *CHELONIA MYDAS* STUDIED IN BRAZILIAN ATLANTIC COAST

Pablo Felipe Cruz Ochoa[1,2,3], Marco Aurélio Gattamorta[1,4,5], Roberta Ramblas Zamana[1,2,3], Silmara Rossi[1,5], Fabiola Eloisa Setim Prioste[1], José Henrique Hildebrand Grisi-Filho[6], Eliana Reiko Matushima[1,3]

[1]Grupo de Pesquisa sobre Fibropapilomatose em Tartarugas Marinhas, Universidade de São Paulo, Brazil
[2]Programa de Pã-Graduação em Patologia Experimental e Comparada, Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil
[3]Laboratório de Patologia Comparada de Animais Selvagens, Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil
[4]Faculdades Metropolitanas Unidas FMU, Brazil
[5]Fundação de Estudos e Pesquisas Aquáticas (FUNDESPA), Brazil
[6]Laboratório de Epidemiologia e Estatística (LEB), Departamento de Medicina Veterinária Preventiva e Saúde Animal, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil

Herpesvirus is associated with fibropapillomatosis (FP), lung-eye-trachea disease and gray patchdiseas e in green sea turtles (*Chelonia mydas*). Lesions in lung are common in weak and cachectic sea turtles and can be caused by bacterial, viral, fungal and parasitic agents. Herpesvirus is the most important viral agent infecting sea turtles, in which the principal lesion is characterized by growing of benign tumor in the skin. In Brazil, FP has been reported around the coast but the role of ChHV5 in other diseases is not well

established in mixed stocks of Brazilian Atlantic coast. In this study, necropsy of twenty-two specimens of C. mydas (9 with FP; 11 classified as cachectic) was carried out. Samples of FP tumors and lung tissues were obtained and analyzed by Polymerase Chain Reaction (PCR) to genes UL-18, DNA-polymerase and F-US-serine-treonine kynases in order to determine the presence of the ChHV5. Eight sampled green sea turtles presented the ChHV5 in the lung samples; thirteen individuals presented a suggestive infectious pneumonia, associated with bacteria (n=3), parasites (n=9) or both (n=1). Nine specimens presented parasitic granulomatous pneumonia, and in six of them (6/9 = 66.6%) the ChHV5 were detected. The same prevalence of ChHV5 were found in bronchopneumonia associated with bacteria (2/3 = 66.6%). The Fisher´s Exact Test did not reveal correlation between the ChHV5 and the parasite or bacteria agent (p=0.7063). The necropsy finding more common was foam material in the lumen of bronchi and trachea (n=10), following by nodular lesion (n=4). Histopathological analysis revealed hemorrhage (n=9), congestion (n=8), parasitic granulomatous pneumonia (n=6) and heterophilic bronchopneumonia (n=6); bacteria was observed in three of these bronchopneumonia, and one nodular lesion was considered fibroma (n=1). A tumor was detected in the lung of one green sea turtle characterized by connective tissue proliferation with relatively mature collagenous tissue, fibrovascular stroma has welldifferentiated fibroblasts and granulomatous response to trematode eggs in septa pulmonary. Four specimens were negative to ChHV5: one of them presented a suggestive infectious pneumonia. These preliminary results indicate that the presence of virus cannot be associated with parasites or bacteria, but this co-infection can be related to immunosuppression condition of the specimens or can reveal tropism of ChHV5 by lung tissues. The low prevalence of fibroma or fibropapilloma in lung could be related the molecular characteristics of the ChHV5 presents in the Brazil, but more researches should be conducted in order to understand the pathogenesis of the virus in mixed stocks of Brazilian Atlantic coast.

BODY CONDITION INDEX OF BLACK SEA TURTLE NESTING FEMALES (*CHELONIA MYDAS AGASSIZII*) IN MICHOACÁN, MEXICO

Carlos Delgado-Trejo[1], Angélica María Rocha-Rodríguez[1], Cutzi Bedolla-Ochoa[1], Vanessa Labrada-Martagón[2]

[1]*Universidad Michoacana de San Nicolas de Hidalgo*
[2]*Universidad Autónoma de San luís Potosi*

Body condition (BC) is a biomarker of the energetic state of animals when working with wildlife, and it is assumed that an animal with higher body condition has greater energetic reserves than an animal with lower index. Knowledge about the health state of adult black sea turtles inhabiting the East Pacific Ocean is lacking. A relative body condition index (Krel) was estimated from the length-weight relationship of 36 black sea turtle females (*Chelonia mydas agassizii*) nesting in Colola beach, Mexico, during 2010-2012. Individuals were classified as healthy or injured according to physical examination. Nesting season was also considered when grouping sea turtles in two periods: maximum nesting activity (October–November) and winter nesters (December). Parametric statistics were applied in order to evaluate differences in body condition index among study groups. The size range of sea turtles captured was 75 - 111.5 cm curved carapace length. The results indicate that, in general, body condition of females captured in Colola beach was good in 2012, presenting a Krel greater than the estimated in juvenile black sea turtles from the west coast of Baja California peninsula (Labrada et al., 2010) as expected. Females classified as injured presented marks of copula, ectoparasites, wounds (broken shell), and gillnets marks, but did not present signs of disease or emaciated condition. There was not found a significant difference in Krel between healthy and injured black sea turtles (t-Student=0.682 $p<0.05$), neither between females that were captured during the maximum nesting period with respect to winter nesters (t-Student=1.855 $p<0.05$). During winter, injured sea turtles presented higher Krel compared with healthy ones (t-Student=2.666 $p<0.05$). The lack

of statistical differences in Krel between females grouped by physical state, and the higher body condition observed in injured female sea turtles during winter, indicates that individuals classified as injured according to external examination did not present poor body condition or a lower nutritional state. Females classified as injured did not present any condition that suggested signs of illness or disease; the most frequent lesions registered in winter nesters were related to mating behavior (62%) and should not be included during future physical health state classification. It is known that the organisms with better condition have greater reproductive success. The lack of differences in Krel between reproductive periods (fall and winter) can be due to the short time period as reported before (Koch et al., 2003); annual differences should be evaluated instead in order to monitor the dynamics of the health state of this important breeding population.

HEMATOLOGICAL AND BIOCHEMICAL PARAMETERS IN BLACK TURTLE POPULATION (*CHELONIA MYDAS AGASSIZII*) OF MICHOACAN, MEXICO

Carlos Delgado-Trejo[1], Angélica Maria Rocha-Rodríguez[2], Cutzi Bedolla-Ochoa[1], Vanessa Labrada-Martagón[3]

[1]Instituto de Investigaciones sobre los Recursos Naturales Universidad Michoacana de San NIcolas de Hidalgo Morelia, Michoacan, México
[2]Facultad de Biologia, Universidad Michoacana de San Nicolas de Hidalgo, México
[3]Universidad Autónoma de San Luis Potosí, San Luis Potosi, México

Sea turtles, like other vertebrates, are susceptible to pathogens such as bacteria, fungi and viruses, the causative causes of diseases, and even to produce mortality. Recent studies in Mexico have emphasized field studies to collect information on the health status of wild populations with an emphasis on endangered species. Hematology and blood biochemistry parameters are some of the approaches that are used in order to determine the health status of reptiles; the former parameters are considered as simple and sensitive biomarkers of nutritional state and health state of sea turtles. In this work, 13 hematological (n=44) and 22 biochemical parameters (n=10) of black sea turtle females (*Chelonia mydas agassizii*) nesting in Colola beach, Michoacán are reported for the first time. Female black turtles were classified as healthy or injured according to physical examination, and were grouped according to the month of capture as follows: maximum nesting activity (October–November) and winter (December). Parametric statistics were applied in order to evaluate differences between study groups. The size range of sea turtles was 75 - 111.5 cm curved carapace length. The average time spent between the capture and the blood sample taken was 8.02 ± 6.9 min; 60% of the individuals were released before 7 minutes. In general, levels of hematological and biochemical parameters of this study coincided with previous reports about green turtle adults (*Ch. mydas*) around the world. Clinical values observed indicate that black turtles nesting in Colola beach are healthy individuals. Five types of leukocytes (lymphocyte, heterophil, eosinophil, monocyte and basophil) were identified in this species as reported elsewhere about sea turtles. Injured sea turtles presented a higher proportion of heterophils (t-Student=3.534, $p<0.05$) and heterophil/lymphocyte ratio (t-Student=2.450 $p<0.05$). Female sea turtles that nested during winter presented higher proportion of heterophils (t-Student=2.037, $p<0.05$) and lower proportion of monocytes (t-Student=-2.200, $p<0.05$), when compared to female nesters captured during the period of maximum nesting activity. During winter, 70% of the sea turtles were classified as injured, being the lesions related to mating behavior the most frequently observed (62%). The former results suggest that injured female sea turtles that nested in winter may present an acute infection that could be related to mating behavior. This is the first record about hematological and biochemical values for the East Pacific green turtle that nest in Michoacán; further studies are required in order to continue monitoring the health state of this population.

CLINICAL AND DIAGNOSTIC PATH OF A RARE CASE OF INTRACELOMIC NEOFORMATION IN A LOGGERHEAD (*CARETTA CARETTA*)

Antonio Di Bello[1], Carmela Valastro[1], Stefano Ciccarelli[1], Erika Ottone[2], Francesco Caprio[1], Daniela Freggi[3], Delia Franchini[1]

[1]*Department of Veterinary Medicine, University of Bari, Italy*
[2]*WWFPolicoro (Mt) Italy*
[3]*Lampedusa Turtle Rescue Center - Lampedusa (Ag) Italy*

In October 2015 we received a male loggerhead: weight 41.8 kg, CCL 76 cm and CCW 67.3 cm. The animal showed a good state of nutrition and was responsive. But in the tank, it showed an inability to dive, remaining inclined on the surface with the right side of its body upward. The serum blood tests showed a decrease in HGB, HCT and MCV and an increase of CPK, AST and total protein. Radiographic examinations showed the presence of an oval neoformation cavity with dimensions 276 x 234 mm in the right caudal portion of the coelomic cavity. The CT scan showed the formation of connections with the caudal portion of the right lung and absence of parenchymal alterations. The descending contrastographic examination of the digestive tract excluded connections with the mass of intestines. An exploratory celiotomy with right groin access was performed. The mass had a tense wall, with gas and abundant necrotic membranes. The strong adhesion formation with surrounding tissues made it not possible to complete its exposure and removal. Histological examination of the training wall showed only fibrous connective tissue inflammation. Microbiological samples from the content of the mass and the coelomic cavities showed fungal infections of *Paecilomyces lilacinus* and Serratia marcescens. The post-operative antibiotic therapy (Ceftazidime, 20mg / kg IM q 72 h for 3 weeks) was associated with long-term antifungal therapy (Itraconazole, 15 mg / kg PO q 48 h for 16 weeks). Four months after the intervention the patient showed improvement and normal flotation in the tank. The subsequent radiographic controls have shown the progressive development of the same formation with the same characteristics and location, in addition to considerable perturbations of density and reduction of the lung fields. The tomographic examination confirmed the reduction of the lung fields, highlighting irregularities in lung density particularly in peribronchial and cranial portions of the lungs. The caudal edge of the lungs were irregular and the right lung severely compressed by the mass. In April 2016 the second exploratory celiotomy was performed for the insertion of an active surgical drain for two weeks. The radiographic exams carried out in the next month showed the adhesion between the walls of the formation without the development of gas. Six weeks after the second surgery the patient died suddenly and necropsy showed intestinal obstruction post-adhesions, multifocal lesions of 5-10 mm scattered on the surface of all the organs and the internal wall of the coelomic cavity, where the *Mycobacterium* spp. was found. The intracelomic mass showed a connection to the posterior margin of the right lung. This work documents a rare case of intracelomic mass: clinical data and the autopsy suggest that it was caused by a fungal lung infection and the death is probably correlated to the bowel obstruction associated with the complications of a serious opportunistic infection.

VENTILATION WITH FiO_2 21% COMPARED TO TRADITIONAL FiO_2 100% IN ANESTHETIZED LOGGERHEAD SEA TURTLES: PRELIMINARY RESULTS

Delia Franchini[1], Antonio Di Bello[1], Giuseppina Carella[2], Stefano Ciccarelli[1], Francesco Caprio[1], Valentina Pastorelli[3], Pasquale Salvemini[4], Carmela Valastro[1,5]

[1]Department of Veterinary Medicine, University of Bari, Italy
[2]Private Practitioner, Bari, Italy
[3]Ospedale Veterinario Santa Fara, Bari, Italy
[4]WWF Turtle Rescue Center, Molfetta (Ba), Italy
[5]Lampedusa Turtle Rescue Center, Lampedusa (Ag), Italy

Rapid, safe, and effective methods of anaesthetic induction and recovery are needed for sea turtles, especially for immediate release. A variety of anaesthetic protocols have been used for surgery in sea turtles, but most result in prolonged recovery periods. Inhalant anaesthetic agents offer many advantages over injectable agents for reptile anaesthesia. In particular, they provide greater intraoperative control over duration and depth of anaesthesia. However, they display different pharmacokinetic properties in reptiles, as compared to mammals. They may also be associated with prolonged recovery periods, particularly in sea turtles, but the response of these animals to a ventilation at 21% O_2 and how this can interfere with the recovery period has never been investigated. The purpose of the present study is to determine whether there is any difference in recovery period between loggerheads ventilated with 21% or 100% O_2, as aquatic animals are likely to experience variation in ambient oxygen. Ten loggerhead sea turtles with flipper lesions were divided randomly into two groups and anaesthetized to perform curettage of one or more flippers. Anaesthesia was induced with propofol (8 mg/kg, IV), maintained with isoflurane in oxygen 21% (FiO_2 21% group A) or oxygen 100% (FiO_2 100% group B) and delivered with a ventilator with a tidal volume of 30 ml/kg and 3 breaths per minute. The loggerhead sea turtles were always maintained in ventral recumbency. Heart rate and rhythm, end tidal partial pressure of CO_2, and cloacal temperature were monitored continuously; venous blood gas analysis was performed intermittently. Administration of isoflurane was discontinued at the end of the surgical procedure. Median induction time was 6 minutes. Median delivered sevoflurane concentration was 2,3%. Median blood gas values were within reference limits in both groups. The results indicate that the recovery period was significantly lower in group A (median 48.2 min) than in group B (median 141.2 min) without significant alterations of venous blood gases. Results suggest that ventilation with isoflurane in oxygen at 21% with a tidal volume of 30 ml/kg and 3 breaths per minute in ventral recumbency is safe and provides faster recovery from anaesthesia compared to traditional FiO_2 100% in loggerhead sea turtles.

HAEMATOLOGY AND HEALTH: A PRELIMINARY STUDY IN RESCUED LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN LAMPEDUSA, SOUTH MEDITERRANEAN

Daniela Freggi[1], Dani Stringer[2], Antonio Di Bello[3]

[1]Lampedusa sea turtle rescue center, Italy
[2]University of Surrey, UK
[3]Vet Dept, University of Bari, Italy

Each year, the Lampedusa Sea Turtle Rescue Centre admits on average one hundred loggerhead sea turtles, rescued primarily by fishermen or members of the public. The animals generally exhibit a condition of poor

health and require some form of veterinary treatment inclusive of surgery. Since2012 the results of haematology analysis have been collected and recorded for many patients, the data divided into groups on the basis of age, lifestyle (wild or under rehabilitation) and presence/type of injury. The aim of this study was to see if there is a correlation between the haematological values and the health status of the patients in order to determine a possible link between clinical and haematological data, to be applied to a better and quicker health assessment of future patients. Blood samples were collected by venipuncture from the dorsal cervical sinus or the jugular vein of 50 loggerheads rescued mainly by fishermen, in a period between 2012 to 2016. Methodology of the blood analysis included; glucose (mg/dL), microhaematocrit (%), serum protein (g/100ml) and the total red blood cell count by use of a Neubauer chamber. Uncoagulated blood smears were also made and the plasma was frozen and stored for possible future analysis. This was done as per the protocol of 'Notes on haematology and Biochemistry of Marine Turtles' by Mariluz Parga (SUBMON). The health status of the patients was derived from the presence of any injuries (i.e. from a hook and/or line, flipper injury, infection or plastic) and the biometric data. Period of residency was also noted to see, if a correlation were established, how it reflects on the amount of time each patient spent at the Rescue Centre. This may suggest how appropriate the release date was for each patient and provide a reference for the more efficient assessment of this in the future.

DIETARY COMPOSITION OF LOGGERHEAD SEA TURTLES IN FLORIDA, USA

Jason Hendershot[1], Erin E. Seney[1], Katherine L. Mansfield[1]

[1]*University of Central Florida Orlando, FL, USA*

Analysis of gastrointestinal contents is an effective tool for understanding the ecology of difficult to study or enigmatic organisms. The loggerhead sea turtle (*Caretta caretta*) is a far-ranging marine species that presents little opportunity to be observed feeding naturally in its environment. Instead, we must rely on piecing together dietary habits through other methods, such as identification of remnants of organisms found within the digestive tracts of stranded turtles. Diet has gone largely unstudied for loggerheads found along the coasts of Florida, but loggerheads found elsewhere in the southeastern U.S. consume a wide spectrum of organisms from crustaceans, to horseshoe crabs (*Limulus polyphemus*), to teleost fishes. We examined digestive tract contents from 33 loggerheads that stranded along the coast of Florida, USA from 2011-2016, with straight carapace lengths (SCL) ranging from 34.0-103.1 cm (average=76.7 cm, SD=14.76 cm). Archived samples from 2012-2015, as well as all relevant accompanying data, were provided by the National Marine Fisheries Service, and 2016 sample collection was conducted in cooperation with the Florida Fish and Wildlife Conservation Commission. Contents from any available portions of the gastrointestinal tract were examined for each sample, including esophagus, stomach, and colon, and identified to the lowest possible taxonomic level. Either wet or pre-dried contents were available for each sample (in several cases both). Results from 28 turtles collected from 2011-2016 indicated that loggerheads commonly consumed crustaceans, such as blue crab (*Callinectes sapidus*, 28.6% occurrence), spider crabs (*Libinia* spp., 28.6%), and flame box crab (*Calappa flamea*, 21.4%), as well as a variety of larger (over 1 cm) gastropods and bivalves. Individuals of prey recorded in diet samples varied widely in number, from 1 to as many as 210, in the case of tulip snails (Fasciolara sp.). Loggerhead diet characterization is a critical component of continued, effective conservation and a measure of the species' diet adaptability. Decreased abundance of common prey species could be a threat to loggerhead populations. However, if variation is seen in their diets across space and time, we hypothesize that in absence of one type of prey, the turtles will be able to rely on other organisms to fulfill their dietary needs. Continued examination of loggerhead turtles' diet in Florida will better refine our understanding of the species' ecosystem roles and habitat use, contributing to science-based natural resource management in the state.

GONADAL SOX9 EXPRESSION, NEST TEMPERATURE AND SEX RATIO IN THE OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA**

Andrea Hernández-Romero[1], Luis Javier Chino-Palomo[1], Martha Harfush-Meléndez[2], Alejandro Marmolejo-Valencia[1], Horacio Merchant-Larios[1]

[1]Departamento de Biología Celular y Fisiología, Instituto de Investigaciones Biomédicas, UNAM. Ciudad Universitaria DF, México.
[2]Centro Mexicano de la Tortuga CONANP-SEMARNAT, Mazunte, Oaxaca, México, UNAM. Ciudad Universitaria, 04510, DF

Eggs of *L. olivacea* incubated at constant temperature found that at 26° C (male promoting temperature: MPT) and 33° C (female promoting temperature: FPT), 100% of hatchlings are male or female, respectively. Furthermore, the incubation period differs considerably: 75 days at MPT and 45 days at FPT. One shift experiment showed that from developmental stage 26 onwards, the embryos fail to respond to a second temperature, maintaining the promoted sex by the initial temperature. Sex determination occurs in the morphologically undifferentiated gonad (formed during stages 22-25) which then differentiates either as testis or ovary. SOX9 is a transcription factor involved in gonadal sex determination in Amniota. Undifferentiated gonads of *L. olivacea* express SOX9 in medullary cords regardless of the incubation temperature. Thereafter, this gene is dimorphically regulated: its expression is maintained at MPT and down regulated at FPT. Since this process occurs prior to differentiation of testes or ovaries, SOX9 is an earlier marker than histology for gonadal sex determination. It has been assumed that the thermosensitive period (TSP) in sea turtles corresponds to the second third of the total incubation time; the laboratory experiments in the Olive Ridley suggest that the TSP is considerably shorter. Here, we compared our laboratory results with those on the beach. To our knowledge this is the first time that a direct comparative study has been undertaken in a sea turtle. The research took place at Morro Ayuta beach, Oaxaca, Mexico; in a small hatchery located near the natural nesting place. Temperature sensors (HOBO) were placed in the center of 25 relocated nests. Four of these nests (NA1-NA4) were analyzed at days 18, 23 and 28, per the following measures: (1) Temperature profile. (2) Gonadal SOX9 expression. (3) Developmental stage, and (4) Sex Ratio. RESULTS: Embryos sampled at 18, 23 and 28 days, were at stages 24, 25 and 26, respectively. All gonads at stage 24, expressed SOX9 in cell nuclei of medullary cords. However, of the embryos analyzed in stage 25, we found gonads with numerous positive cells whereas in other gonads we found positive and negative cells to SOX9 expression. At stage 26, differentiated testes or ovaries were SOX9 positive or negative, respectively. The mean temperature of nests NA1-NA4, monitored during days 18-28 were: 31.42ºC, 30.65ºC, 30.91ºC and 31.52ºC and the sex ratio was established at day 38 (stage 29): 63% Male, 75% Male, 91.6% Male and 75% Male, respectively. In embryos sampled in other 21 nests, the sex ratio was correlated with the mean temperature monitored during 18-25 days. Male production was 100% in 9 nests (31.07/30.44°C). In 7 nests sex ratio was highly variable (31.52/30.60°C). Moreover, female production was 100% in 10 nests (34.82/32.6°C). CONCLUSION: The dimorphic regulation of SOX9 strongly suggests that the period for TSD takes around eight days which is almost half the second third of incubation time previously proposed.

LONG-TERM PATTERNS OF FIBROPAPILLOMA OCCURRENCE IN JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) IN A CENTRAL FLORIDA FORAGING HABITAT

Abby Hudak[1], Christopher A. Long[1], Katherine L. Mansfield[1]

[1]*University of Central Florida Orlando, FL, USA*

Within a 25-year period, approximately 22% of *Chelonia mydas* strandings in Florida have been affected by the fibropapilloma (FP) disease according to the Florida Sea Turtle Stranding and Salvage Network. The University of Central Florida Marine Turtle Research Group (UCFMTRG) has been collecting in-water data, including fibropapilloma tumor prevalence, of sea turtles captured in the Indian River Lagoon (IRL) since 1983. Our goal is to use these long-term data to evaluate three hypotheses: 1) smaller turtles are more likely to be afflicted by FP; 2) larger turtles are more likely to have regressed tumors and 3) recaptured individuals will have lower tumor scores and/or regression than when initially captured. Juvenile green turtles in the IRL are generally not considered to be new recruits from oceanic environments, making it a useful area of study to examine the temporal patterns of FP. From 2005-2014, juvenile green turtles averaged 41.6 cm SCL, with 50.1% of turtles having FP. Individuals with no FP averaged 48.0 cm SCL, lending preliminary support to our hypothesis that smaller turtles are more likely to be afflicted by the disease. Of the 719 turtles captured from 2005-2014 that had tumors present, 148 turtles showed signs of regression. A 2008 UCFMTRG study showed that affected turtles that had been later recaptured showed a decrease in tumor severity in the IRL and 40% of the recaptures with the tumors had regressed completely (Borrowman 2008). Recognition of temporal aspects of the fibropapilloma disease is important to better understanding how and when the disease is affecting turtles. Positive correlations have been shown between polluted water and the frequency of fibropapilloma incidences suggesting degraded habitats may lead to higher incidences of the disease. The IRL serves as an important developmental habitat for juvenile green turtles from nests laid throughout the Caribbean. By understanding how and when turtles in degraded habitats are afflicted by the disease, we will be able to implement better conservation strategies in areas impacted by humans.

UNCOMMON SCUTE LESIONS IN LOGGERHEAD SEA TURTLE, *CARETTA CARETTA*, IN THE SOUTH WEST INDIAN OCEAN

Claire Jean[1], Joseph Dando[1], Mathieu Barret[1], Francis Schneider[2], Stéphane Ciccione[1]

[1]*Kelonia*
[2]*Vetorun*

Scute lesions have been observed in loggerhead sea turtles rescued by Kelonia's clinic after incidental catch by local longline fisheries operating in the French EEZ around Reunion from 2010 to 2016. The symptoms, already present at turtles' arrival, consisted in black patches covering mainly the rear of the carapace, and also the vertebral scutes or more for the individuals most affected. These black patches appeared as a result of decomposition of the underlying scutes that turned completely black, while the overlying scutes peeled away. After spending almost one month at the clinic, new layers of keratin covered the shell again, and the scutes turned back to their natural orange-brown colour despite any specific treatment on the carapace besides prophylactic treatments. A method based on photographs taken at arrival was developed to quantify the proportion of carapace affected, and to monitor the evolution of these lesions after arrival at the clinic. Several analyses were conducted to identify their origin: bacteria, mycosis, dietary deficiency, trauma, or

pollution. A sample of 44 loggerhead turtles was studied overall the turtles rescued from 2010 to 2016. Among this sample, the disease affected 37 individuals (84%) on a mean proportion of 38% of the scutes (min = 3%; max = 88%; SD = 21%). Results also revealed an increase in the number and proportion of turtles affected since the beginning of the study. First results obtained from the analyses conducted revealed no correlation with plastic debris excretion, despite high quantities released and collected in the faeces during at most two weeks spent at the clinic (15.05 g ± 19.91). Bacteriology analyses revealed the presence of several bacteria commonly observed in sea turtles including *Citrobacter freundi*, which was found in 2 samples (N=10). Fungal cultures of carapace were positive in 3 samples (N=7), and yielded to the identification of *Fusarium* sp. histology analyses are still in progress. Despite apparently healthy turtles and no obvious sub-lethal or lethal effect on the turtles, at least after treatment in a clinic, these lesions should be further investigated as a large part of the turtles rescued are affected (88% in 2016), and in order to better understand the causes of this phenomenon that may illustrate the degradation of sea turtle's environment.

MARINE DEBRIS INGESTION BY GREEN TURTLES (*CHELONIA MYDAS*) IN NORTHERN PERU

Astrid Jiménez-Heredia[1], Sergio Arturo Pingo-Paiva[1], Joanna Alfaro-Shigueto[1], Jeffrey C. Mangel[2]

[1]ProDelphinus, Lima, Peru
[2]University of Exeter, Cornwall, UK

Plastics are a major contaminant of the marine environment and marine debris ingestion can have lethal and sub-lethal effects on sea turtles and other fauna. We analyzed the marine debris ingested by green turtles (*Chelonia mydas*) through sampling of digestive tracts of dead specimens caught incidentally by the artisanal gillnet fishery in Sechura Bay, northern Peru between July 2013 and June 2014. Twenty-seven digestive tracts of C. mydas were examined. The specimens sampled were 86.7% juveniles and 13.3% subadults (LCC: 52.7 ± 1.8 cm; range: 40.5 to 66.5 cm). We found that 55.6% of sampled turtles had ingested some type of marine debris, specifically, black bags, white bags, transparent bags, labels (cookies / oils), nylon and raffia/rope, also an additional item (e.g. feathers). Transparent bags had the highest frequency of occurrence (n = 10, FO = 66.7%), while additional items had the lowest FO value (n = 3, FO = 20%). This study highlights the potentially serious problem marine pollution presents to the *C. mydas* population in Sechura Bay. To address this risk we recommend that future conservation plans (e.g. land use planning) directly address management of anthropogenic debris and include green turtles as a sentinel species for monitoring marine pollution in the Sechura Bay.

DEVELOPMENT OF TECHNIQUES FOR ARTIFICIAL INSEMINATION IN CAPTIVE HAWKSBILL TURTLES

Isao Kawazu[1], Miwa Suzuki[2], Masakatsu Kino[1], Konomi Maeda[1], Yutaka Sawamukai[3]

[1]Okinawa Churashima Foundation, Okinawa, Japan
[2]Nihon University, Kanagawa, Japan
[3]Yokoo Veterinary Clinic, Tochigi, Japan

Artificial insemination is one of the techniques to assist in the recovery and conservation of endangered species. However, to date, viable artificial insemination techniques have not been developed for the

Hawksbill turtles (*Eretmochelys imbricata*). This study provides information on a semen collection technique, ovulation, and oviposition-induction techniques leading to the improvement of the artificial insemination techniques for the turtles. Electro-ejaculation is a practical tool for semen collection in hawksbill turtles, and many surviving sperms (up to 7769.1 × 106/individual) were obtained from male turtles kept in isolation for 1–2 years between the onset of spermatogenesis (winter) and mating season (spring or summer). Ovulation in captive female hawksbills would occur 2–9 days after mating, as indicated by the daily serum progesterone monitoring between mating and first nesting, and the delay may be providing time for semen to reach the sperm storage tubules of the oviduct. Administration of follicle-stimulating hormone (FSH) to female hawksbills effectively induced ovulation and egg formation 1 and 2 days after the administration, respectively, and these artificially formed eggs were oviposited by oxytocin administration. These data indicate that artificial insemination should be carried out according to the following procedure: (1) inject semen collected by electro-ejaculation into females, (2) administrate FSH to the females 2–9 days after semen injection to induce ovulation, and (3) administrate oxytocin to trigger oviposition. These suggestions provide the significant first steps for successful artificial insemination of hawksbill turtles and help in furthering our knowledge on the reproductive physiology and ecology of hawksbill turtles.

TEMPORAL ANALYSIS OF CHELONID FIBROPAPILLOMA-ASSOCIATED HERPESVIRUS (CFPHV) PREVALENCE IN JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) AT TWO COASTAL FORAGING GROUNDS*

Jacob R. Kelley[1], Matthew Lawrance[1], Anna Savage[1], Katherine L. Mansfield[1]

[1]*University of Central Florida, Orlando, FL, USA*

Fibropapillomatosis (FP) is a widespread disease in sea turtles that most commonly affects juvenile green turtles (*Chelonia mydas*) in coastal foraging habitat. Turtles afflicted with FP may develop tumors on the skin, eyes, and internal organs that could hinder survival. The etiology of FP is not fully understood, but is likely linked to chelonid fibropapilloma-associated herpesvirus (CFPHV), along with other environmental and immunological factors. To better understand the role of CFPHV in the development of FP in juvenile green turtles, FP and CFPHV prevalence will be characterized for two foraging grounds on the East Central Florida (USA) coast, each with long-term datasets – the Indian River Lagoon (IRL, 1982-2016) and Trident Submarine Basin (TSB, 1993-2016). The two sites differ in their historical FP prevalence. In the IRL, FP prevalence has stayed relatively stable at about 50% throughout the study period. However, in TSB there were no records of FP for the first 11 years of the study; then FP first appeared in TSB in 2005, and prevalence gradually increased thereafter. To investigate the temporal relationship between CFPHV and FP, we determined the prevalence of CFPHV for each site during two-time frames: before and after the appearance of FP in the TSB foraging aggregation. CFPHV prevalence was determined using polymerase chain reaction (PCR) techniques. This study reveals whether CFPHV was prevalent in TSB turtles before the outbreak of FP in the aggregation. CFPHV may have been present in these turtles before FP appeared in the aggregation, but the environmental conditions that promote tumor growth may not have been met. Alternatively, if CFPHV was not present in the TSB aggregation before, then the arrival of CFPHV would likely have led to the FP outbreak. The results of TSB will be compared to the IRL, where FP prevalence has been steady. By comparing CFPHV rates in TSB to the IRL, we can see whether CFPHV prevalence or site-specific conditions are better predictors of FP prevalence. Also, from both sites we will see what baseline CFPHV prevalence exists relative to FP prevalence, and if that baseline is changing over time. Overall, we will characterize the historic background of CFPHV in juvenile foraging grounds to better understand how it has affected these foraging aggregations in the past so we can know what to expect in the future.

METHODS FOR DOCUMENTING AND IDENTIFYING INJURIES ON LEATHERBACK SEA TURTLES, *DERMOCHELYS CORIACEA*, AT SANDY POINT NATIONAL WILDLIFE REFUGE

Courtney King[1], Claudia Lombard[2], Kelly R. Stewart[3]

[1]*Miami University, Oxford, OH 45056*
[2]*Sandy Point National Wildlife Refuge, Frederiksted, USVI 00840*
[3]*The Ocean Foundation, Washington, DC 20036*

Leatherback sea turtles, *Dermochelys coriacea*, migrate to their nesting beaches every 2-7 years and they often arrive with a myriad of injuries with varying degrees of severity. However, very little is known about the frequency of injuries each population is sustaining, the cause of the injuries or how long the healing process might take. Since leatherbacks are unable to be kept in an aquarium, rehabilitation for injuries has been problematic. Therefore, monitoring injuries during the nesting season gives researchers a unique opportunity to study injuries and healing rates because the same individuals may be reliably encountered every 10-14 days. This provides a rare opportunity to examine a turtle repeatedly over the course of a few months. Some sea turtle nesting projects have been collecting basic injury diagnostics for many seasons; however, it is hard to assess and compare between projects due to lack of consistency of injury classification procedures. We systematically examined the physical injuries present on nesting leatherbacks on Sandy Point National Wildlife in Saint Croix, USVI to develop a scoring method for injuries and to assess the level of healing over time. Here we detail the methods of documenting and scoring injuries. We used photo documentation throughout the nesting season to identify new injuries and to follow the healing process of each of the injuries on the nesting females. Stages of healing were identified and ranked on a scale from 1 to 5 based on the following criteria: 1) being fresh with blood present, 2) injury was still fresh, but without blood, 3) the injury was not fresh, but there were no signs of new tissue growth, 4) edges of the injury were pink with new tissue growth and 5) pink scarring was present. There were 4 distinct injury types noted. The main injury type seen at Sandy Point was large gashes or chunks of flesh missing from their shoulders. However, there was a bizarre injury present in 34% of the injured nesting females in 2014 that consisted of 3-7 equally-spaced scrapes across the head and a gash on the underside of the neck. The other two injury types were the loss of a portion of a flipper and scraping to the carapace. Being able to identify the age of the injury may help researchers move toward finding probable causes of injuries, and help with population level threat assessment, which is important for improving recovery plans and mitigating future injuries. Furthermore, our methodology provides a framework for standardizing data collection of leatherback injuries, enabling comparison of injuries across different nesting beaches.

PARALYTIC SHELLFISH POISONING (PSP) AS POSSIBLE CAUSE OF SEA TURTLE MORTALITY IN THE MEXICAN PACIFIC COAST C.P.*

César Paúl Ley-Quiñónez[1], Catherine E. Hart[1], R. Alonso-Rodríguez[2], Renato Leal-Moreno[1], Brenda Aracely Espinoza-Romo[1], Alexis Antonio López-García[1], Carlos Gregorio Romero-Urías[1], A.G. Sandoval-Lugo[1], M.R. Vejar-Rubio[1], Kevin Alan Zavala-Félix[1], Edna G. Meza-González[1], P. Aguilar-Claussell[1], A. Alonso Aguirre[3], Alan A. Zavala-Norzagaray[1]

[1]Instituto Politécnico Nacional CIIDIR- SINALOA, México
[2]Instituto de Ciencias del Mar y Limnología, UNAM, México
[3]Department of Environmental Science and Policy, George Mason University, Fairfax, Virginia USA

During February-June 2016, a sea turtle mortality in the Mexican Pacific coast was observed. Federal Attorney of Environmental Protection (PROFEPA, by its acronym in Spanish: Procuraduría Federal de Protección al Ambiente) issued, in official report, a total of 602 dead turtles: 118 in Oaxaca, 322 in Guerrero, 84 in Jalisco, 30 in Nayarit and 48 in Sinaloa. It was mentioned that possibly, the apparent death was due to respiratory problems as a consequence of a parasite called spirorchiid trematodes (*Spirorchiidae* spp.). In April of the year in progress, PROFEPA delegation from Jalisco state requested support from the CIIDIR-SIN of the National Polytechnic institute, to analyze the possible mortality cause in Puerto Vallarta Beach, México. Of the stranded turtles that PROFEPA collected, two sea turtles *Chelonia Mydas agassizii*, without an advanced decomposition state, were performed at necropsy. During the procedure a great salps abundance (tunicates, Family Salpidae) in the both turtles stomach was observed. The stomach content and muscle sample were collected for lab analysis. In the Bay, a great abundance of salps was observed in the water. Some specimens and water were collected for lab analysis. Four turtle *Lepidochelys olivacea* were observed. The organisms showed lethargy, disorientation, lack of motor coordination and difficulty breathing and with submersions. Two turtles were captured for rehabilitation and blood sample collection. Captured turtles were rehabilitated for five hours. Esophageal wash was performed, and activated carbon was applied, as an absorbent agent for treating poisonings. Both turtles reacted positively to the treatment and were released at sea. From collected salps, stomach content samples were extracted for plankton species identification. Toxic dinoflagellates *Pyrodinium bahamense* were identified. This species can produce a derivative called Saxitoxin (Stx), principal toxin responsible for Paralytic shellfish poisoning (PSP). In the same way, other toxic phytoplankton species were identified, like *Chattonella* spp. and *Pseudonisquia* spp., associated to Harmful Algal Blooms (HAB). Rehabilitated turtles blood samples and muscle samples obtained during the necropsy were analyzed by High-Performance Liquid Chromatography with Fluorescence Detection (HPLC-FD) and Enzyme-Linked ImmunoSorbent Assay (ELISA). PSP were detected in all muscle and blood samples. Four derivatives were detected in muscle: GTX 2,3, GTX 5, C1,2, dc STX. In blood were detected dcSTX y C1,2. Sea turtle mortality in the Mexican Pacific coast may be related to the consumption of prey contaminated with PSP toxins. Photographic evidence of Pyrodinium bahamense in salps and the derivatives detected correspond to the toxic profile of this species. The presence of another dinoflagellate, Gymnodinium catenatum, is not ruled out by the presence of C1,2-type toxins. Sea turtles can be considered sentinels of ecological health and harmful phenomena like a HAB, even when it is not visible at simple sight (Red Tide).

EXPLORING OPTIMIZED FEEDING PROTOCOLS ON CAPTIVE LOGGERHEAD TURTLES

Ana Liria-Loza[1], Saray Jimenez-Bordon[2]

[1]University of Las Palmas de Gran Canaria
[2]ADS Biodiversidad

Loggerhead sea turtle (*Caretta caretta*) is a remarkable example of migratory species globally threatened. Resource acquisition influences growth rates, health conditions, breeding frequencies and behavior in all species, including marine turtles at all developmental stages. Knowledge on food preferences of each species is complex, especially those that have large oceanic stages. Along their lives, loggerhead turtles exhibit several ontogenetic shifts that include changes on diet and habitat. Therefore, there is a strong influence of resource acquisition on specific requirements of each life stage. Nowadays, specimens of different species of sea turtles are kept in captivity (temporary or prolonged) for a great variety of reasons: recovery of injured or sick individuals, unrecoverable animals, head-starting programs, educational programs, etc. Establishing specific requirements for these individuals is important to improve the wellness of those animals kept in captivity. In the Canary Islands there is a stock of 25 turtles -deriving from the project "Enlargement of loggerhead breeding area in the Macaronesia region", through a Loggerhead Reintroduction Program on Canary Islands-, kept in captivity for studies and try to understand the specific changes in life stages on loggerhead turtle. Identifying specific dietary requirements for different developmental stages is very important to ensure a proper development and wellness of any individual kept in captivity. Two years of study has allowed to establish adequate feeding protocols for loggerhead turtles, adjusted to age, thermal variations and individual's activity.

DIATOMS ON SEA TURTLES: A SUMMARY OF RECENT DISCOVERIES

Roksana Majewska[1], Nathan J. Robinson[2,3], Eric A. Lazo-Wasem[4], Ronel Nel[5], Frank V. Paladino[2,3], Lourdes Rojas[4], John D. Zardus[6], Theodora Pinou[7]

[1]Unit for Environmental Sciences and Management, North-West University, Potchefstroom 2520, South Africa
[2]The Leatherback Trust, Goldring-Gund Marine Biology Station, Playa Grande, Guanacaste, Costa Rica
[3]Department of Biology, Indiana University-Purdue University Fort Wayne, Fort Wayne, Indiana, USA
[4]Division of Invertebrate Zoology, Peabody Museum of Natural History, Yale University, New Haven, Connecticut, USA
[5]Institute for Coastal and Marine Research, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa
[6]Department of Biology, The Citadel, 171 Moultrie Street, Charleston, South Carolina, 29407, USA
[7]Department of Biological and Environmental Sciences, Western Connecticut State University, Danbury, Connecticut, USA

The first reports of diatoms growing on marine mammals date back to the early 1900s; however, only recently has direct evidence been provided for similar associations between diatoms and sea turtles. The turtle-associated diatom communities appear to be composed of a few, well-adapted species that sometimes reach very high abundance. Many of the newly observed taxa exhibit unique morphology and high resistance to rapidly changing external conditions. Furthermore, many of the sea turtle diatoms represent new species and genera. These taxa have only been observed growing on sea turtles and are thus presumably

exclusively epizoic or even specific to sea turtles only. Although the diversity of marine epizoic diatoms is still largely unknown, the ongoing studies indicate that different diatom communities may exist on both different sea turtle species and different body parts of the same specimen (carapace vs. skin). These observations highlight the importance of substrate type for the diatom community development suggesting a unique relationship between the host organism and its epibiont. Here, we present a summary of the recent findings on the sea turtle diatoms. These results have come from the examination of carapace samples from multiple individuals of several sea turtle species, including museum specimens. Using Scanning Electron Microscopy and techniques involving Critical Point Drying, we were able to observe diatoms still attached to turtle carapace and reveal interesting aspects of their ecology, including growth form structure and attachment strategies. Diatom cells were usually surrounded by large amounts of exopolymeric matrix, which may act as protective coating preventing the excessive desiccation of both diatom cell and turtle carapace during the longer periods out of water. Interestingly, some of the diatom species were observed in samples collected from different turtle species and even from different ocean basins. This suggests that typically epizoic diatoms may be found comprehensively on sea turtles throughout their range and may further indicate an important co-evolutionary relationship between these taxa and sea turtles. Investigation of sea turtle associated diatom communities may open many new avenues for further research into diatom evolution and biogeography, their physiological ability to colonize various (extreme) habitats, as well as their capacity to function as ecological indicators of sea turtles' behaviour.

PREVALENCE AND HOST PATHOLOGY OF SPIRORCHIIDIASIS IN STRANDED LOGGERHEADS (*CARETTA CARETTA*) IN NORTH WESTERN ADRIATIC SEA

Federica Marcer[1], Enrico Negrisolo[1], Lisa Poppi[1], Cinzia Tessarin[1], Luisa Garofalo[2], Cinzia Centelleghe[1], Erica Marchiori[1]

[1]*University of Padova, Italy*
[2]*Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana, Italy*

The Adriatic Sea represents an important foraging area for subadult and adult loggerhead turtles. Cardiovascular flukes (Digenea: Spirorchiidae) are considered worldwide an important cause of stranding and mortality in sea turtles, including loggerheads. The presence of adults in the heart and vessels and the spreading of eggs to various organs can lead to severe vasculitis, thrombosis and development of disseminated granulomas. *Hapalotrema mistroides* is the only species historically reported in the Mediterranean Sea, but updated data on species and prevalence still lack. The aim of this study was to investigate presence and pathological lesions of spirochiidiasis in *C. caretta* spanning over the Mediterranean Sea. Two hundred five carcasses of *C. caretta* stranded along the Italian coastline of the Northern Adriatic Sea between June 2013 and October 2016 were submitted to necropsies and parasitological analyses in order to detect spirorchiids infection (research of adult blood flukes in cardiovascular system, detection of Spirorchiid eggs in spleen and in faecal samples by sedimentation and flotation procedure). Tissue samples from different organs were formalin-fixed, paraffin-embedded and routinely processed for histological examination in order to detect Spirorchiid eggs and lesions. Adult flukes and eggs (type: 1, 2, 3) were morphologically identified according to the available literature references. Internal transcribed spacer 2 region (ITS2) from parasitic elements was amplified and sequenced for comparison with data in literature. In order to identify the possible origin of the infected turtles, sequences of mtDNA encompassing the D-loop region were analyzed. Spirorchidiiasis was detected in thirty-four animals (16.6%). *Hapalotrema* and *Neospirorchis* infection were found in seventeen and two cases respectively, while mixed infections were observed in additional fifteen animals. Adult parasites of the genus *Hapalotrema* were found in six animals; no adult flukes of genus *Neospirorchis* were isolated. Spirorchiid eggs were observed in faecal samples of thirty-three infected turtles, while in one positive

animal the eggs were detected only in the spleen. Molecular identification unambiguously assigned the spirorchiid samples to the taxa *Hapalotrema mistroides* and *Neospirorchis* sp. In particular, ITS2 sequences obtained from eggs type 3 matched with those of *Neospirorchis* sp. Neogen 11 sequence, obtained from a specimen previously isolated from the gastrointestinal tract of *C. caretta* in Florida. Only mild lesions were observed: eggs of type 1 and 3 were grossly visible in the gastrointestinal mucosa; focal vasculitis was rarely observed in heart and great vessels, while miliary granulomas were widespread in the tissues. Genetic analyses, made on the D-loop region of mitochondrial DNA, pointed to a Mediterranean origin of the turtle hosts. This survey provides new data on the spreading of spirorchiidiasis in Mediterranean loggerhead population, reporting for the first time *Neospirorchis* genus in this basin and confirming the presence of *H. mistroides*. In this study spirorchidiasis seems not to have severely affected the health status of the host, being associated with mild lesions in all districts.

PATHOLOGICAL FINDINGS IN SEA TURTLES STRANDED ALONG THE NORTH WESTERN COAST OF THE ADRIATIC SEA*

Erica Marchiori[1], Lisa Poppi[1], Cinzia Centelleghe[1], Maria Luisa Menandro[1], Daniela Pasotto[1], Nicola Novarini[2], Giuseppe Palmisano[1], Federica Marcer[1]

[1]*University of Padova, Italy*
[2]*Museum of Natural History of Venice, Italy*

The North Adriatic Sea represents one of the most important foraging grounds for loggerheads (*Caretta caretta*) in the Mediterranean basin. Nevertheless, the area is also intensively exploited by anthropic activities; according to literature, bycatch and boat strikes represent most relevant causes of death for turtles in the area, though only sparse studies have been carried out on pathological issues on stranded animals. Sea turtle strandings along Veneto coast (north western Adriatic) were monitored in the period 2013-2016, thanks to a collaboration with institutional Authorities, WWF Italy, Museum of Natural History of Venice and many others, in the framework of the European IPA Project NETCET. Dead animals were transferred to Padua University to perform necropsy and subsequent analyses. A total of 252 carcasses were transported to the necropsy room; 172 out of these were in advanced decompositional state or mummified. When preservation conditions allowed it, life stage (N=233) and sex (N=176) were assigned according to biometric data and gonad inspection; gross lesions were investigated (N=138) and histological (N=59), bacteriological (cultures and molecular analysis) (N=68), parasitological (N=205) and virological (Transmission Electron Microscope -TEM) (N=4) analyses were performed. Whenever possible, a death cause was formulated. Badly preserved or mummified turtles were also included for evidence of human interaction (boat collisions, entanglement, hooks, lines). Carcasses in the study period (N= 37 in 2013, N= 71 in 2014, N= 100 in 2015, N= 44 in 2016) were distributed in 3 age classes as follows: juveniles N=68 (38 females, 15 males, 15 undetermined), subadults N=129 (60 females, 33 males, 36 undetermined), adults N=35 (19 females, 8 males, 8 undetermined). The most frequent finding was multifocal hydrodynamic imbalance (N=93), showing as: mild to severe multifocal hemorrhagic edemas (especially perirenal, subcutaneous and on muscular masses; N=66), severe sero-hematic effusions in celomic and pericardial cavities (N=45), moderate internal organs congestion (N=25), often associated with diffuse, moderate to severe, acute to subacute enteritis (N=28). Lesions connected to anthropic interaction were seen in 19 turtles, including acute, fatal (N=6) and chronic injuries (N=7) by boat impact, amputated limbs from line entanglement (N=4) and mortal ingestion of hooks and lines (N=2). Moreover, plastic debris was collected from gut content of 4 over 113 observed carcasses. Anemia and cachexia syndrome was detected in 6 turtles. The most frequently isolated bacterial strain was *Photobacterium damselae damselae* (N=13), isolated from intestinal tract (N=11), heart (N=6) and central nervous system (N=1); in 4 animals the strain was isolated from more than one district. Research of virions from the intestinal tract by TEM were

negative. Ectoparasite leeches (*Ozobranchus margoi*) (N=15/ 155), gastrointestinal helminth parasites belonging to 7 taxa (N=82/113) and spirorchidiasis infection (N=34/205) were also detected. Unusual and still unexplained peaks of mortality were observed in autumn 2014 and summer 2015, when the number of dead turtles just in the period June-July 2015 clearly exceeded the total annual amount of the year 2013 and of 2016. Pathological and collateral analyses, such as microbiological and parasitological findings, are widely discussed to highlight possible hypotheses to explain the exceptional events.

TREATMENT PROTOCOLS FOR ENDANGERED SEA TURTLES EXPOSED TO BREVETOXIN DURING HARMFUL ALGAL BLOOMS*

Sarah L. Milton[1], Courtney Cocilova[1], Gregory Bossart[2], Leanne Flewelling[3]

[1]*Florida Atlantic University*
[2]*Georgia Aquarium*
[3]*Florida FWC*

The dinoflagellate *Karenia brevis* is one organism responsible for harmful algal blooms (HABs) that severely impact marine life, including sea turtles. *K. brevis* produces brevetoxins (PbTx) which bind to voltage-gated sodium channels, increasing cell permeability and leading to excitotoxic cell death. Brevetoxicosis is difficult to treat in sea turtles as the physiological impacts have not been investigated and the magnitude and duration of brevetoxin exposure are generally unknown. As sea turtles are all listed as threatened or endangered, these questions cannot be experimentally addressed, making it difficult to design appropriate treatments. We developed the freshwater turtle, *Trachemys scripta*, to use as a model for brevetoxin exposure. Turtles were exposed either orally or intratracheally to PbTx-3 and tissues were collected for ELISA to investigate PbTx-3 uptake and distribution, route of excretion, and rates of clearance (1h-1wk post-exposure). PbTx-3 was widely distributed in all tissues and fluids following both intratracheal and oral exposures, but was largely cleared from the system within 24 hours. PbTx-3 moved into the bile and feces over 48h post exposure indicating that this is the main route of excretion. While exposed animals showed clear clinical symptoms of toxicity, there was no evident tissue pathology. Turtle neurons are surprisingly resistant to PbTx-3; although cell viability decreased in a dose dependent manner. Based on the physiology of brevetoxin effects, we suggest treatment strategies that can be implemented to reduce the number of sea turtle deaths from PbTx-3 exposure, including those aimed at reducing neurological symptoms and increasing toxin clearance rates. To test treatment protocols, animals were administered one dose of PbTx-3 via intratracheal instillation. Intralipids (ILE, 100 mg/kg) were administered i.v. to animals 30 minutes pre- or post- toxin exposure. Animal behavior was monitored to compare brevetoxin symptoms post-intralipid treatment vs untreated animals. Animals were sacrificed either 1h or 24h post toxin exposure and tissues and fluids were collected for ELISA to examine tissue distribution and rates of clearance. PbTx-3 exposed T. scripta experience symptoms of brevetoxicosis for at least 10-12 hours post-exposure and recover within 24 hours except for persistent lethargy. Animals treated with the Intralipids post PbTx-3 exhibited less severe symptoms and appeared fully recovered 6h post-PbTx-3 whereas untreated animals still exhibited significant behavioral deficits. PbTx-3 also appeared to clear from tissues more rapidly than in controls. Animals that received ILE treatment prior to PbTx-3 experienced no to few signs of brevetoxicosis.

BLOOD GASES, BIOCHEMISTRY, AND HEMATOLOGY OF GALAPAGOS HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*)*

Juan Pablo Muñoz-Pérez[1,2], Gregory A. Lewbart[3,1], Maximilian Hirschfeld[1,2], Daniela Alarcón-Ruales[1,2], Judith Denkinger[1,2], Jason Guillermo Castañeda[1,2], Juan García[4], Kenneth J. Lohmann[5,1]

[1]*Galapagos Science Center*
[2]*Universidad San Francisco de Quito*
[3]*North Carolina State University*
[4]*Parque Nacional Galapagos*
[5]*University of North Carolina Chapel Hill*

The hawksbill turtle, *Eretmochelys imbricata*, is a marine chelonian with a circum-global distribution, but the species is critically endangered and has nearly vanished from the eastern Pacific. Although reference blood parameter intervals have been published for many chelonian species, including nesting Atlantic hawksbills, no such baseline biochemical and blood gas values have been reported for wild Pacific hawksbill turtles. Blood samples were drawn from nine hawksbill turtles, three of which were re-sampled on three occasions, captured in near shore foraging locations within the Galápagos archipelago. Of these turtles, five were immature and of unknown sex, and the other four were females. A portable blood analyzer (iSTAT) was used to obtain near immediate field results for pH, lactate, pO_2, pCO_2, HCO_2, Hct, Hb, Na, K, iCa, and Glu. Parameter values affected by temperature were corrected in two ways: (1) with standard formulas; and (2) with auto-corrections made by the iSTAT. The two methods yielded clinically equivalent results. An IDEXX 8008 VetTest bench top analyzer was used to measure creatinine, CK, TP, ALKP, ALT, AMYL, BUN, and AST. Standard laboratory hematology techniques were employed for red and white blood cell counts and to determine hematocrit manually, which was compared to the hematocrit values generated by the iSTAT. The values reported in this study provide reference data that may be useful in comparisons among populations and in detecting changes in health status among Galápagos sea turtles. The findings might also be helpful in future efforts to demonstrate associations between specific biochemical parameters and disease or environmental disaster.

RAPID ASSESSMENT OF FEMALE LOGGERHEAD (*CARETTA CARETTA*) BODY CONDITION USING EPIBIONTS

Christopher Nolte[1], Ronel Nel[1], Maya Pfaff[2]

[1]*Nelson Mandela Metropolitan University, Port Elizabeth, South Africa*
[2]*Department of Environmental Affairs, Cape Town, South Africa*

Humans impact the habitats sea turtles depend on through harvesting, pollution and habitat degradation. Consequently, sea turtle populations globally are declining and there has been an increase in the occurrence of injuries sustained through anthropogenic impacts from boat strikes and fishing, and an overall decline in their body condition and health. Overall, a poorer body condition can result in a loss of fitness. It is therefore important to be able to assess and monitor the body condition of sea turtles efficiently using a method that is accurate and will provide information that could be comparable between populations. Currently, some of the methods, such as weighing or taking blood and tissue samples, used to examine body condition are difficult to implement, especially in developing countries or remote areas. Turtle epibionts have previously been proposed as a cost-effective proxy for a body condition, where higher

epibiont loading indicates a poorer body condition. The aim of this project was to investigate the relationship between body condition and epibiont loading of loggerhead sea turtles (*Caretta caretta*) nesting on South African beaches. To achieve this, female loggerhead turtles were sampled during the nesting season from December 2015 to January 2016. A body condition index was created to rank these individuals on a scale from very poor (0) to very good (5). Injuries, skin deformities, neck circumference to length ratio and plastron shape were used to categorise the turtles' body condition. Epibionts from these turtles were collected, counted and identified. We compared epibiont community composition, species richness and barnacle loading among the five body condition ranks. The results indicated that epibiont community composition was related to body condition, with a higher abundance and species richness of epibionts occurring on turtles with poorer body conditions. Barnacle epibionts showed the greatest variation among the body conditions, as both barnacle cover (%) and relative barnacle density (no.m-2) were highest on turtles in poorer body condition. The results of this study therefore suggest that epibiont loading can be used as an indicator of body condition for South African nesting loggerhead turtles. Measuring the epibiont load, and particularly that of the barnacles, is a simple and straightforward method that can be applied in the field to provide a quick assessment of a turtle's body condition. The fact that all parameters investigated in this study, including epibiont assemblage structure and diversity, as well as barnacle loading showed distinctive relationships with the body condition of loggerhead turtles, emphasised the value of epibionts as effective and reliable indicators for population health.

PHARMACOKINETICS OF MELOXICAM IN LOGGERHEAD (*CARETTA CARETTA*), KEMP'S RIDLEY (*LEPIDOCHELYS KEMPII*), AND GREEN (*CHELONIA MYDAS*) SEA TURTLES AFTER SUBCUTANEOUS ADMINISTRATION*

Terry Norton[1], Sherry Cox[2], Tonya Clauss[3], Stephanie Stowell[1], Carrie Thistle, Rachel Sommer[1], Allison Hardman[1], Michelle Kaylor[1]

[1]*Georgia Sea Turtle Center/Jekyll Island Authority*
[2]*University of Tennessee College of Veterinary Medicine*
[3]*Georgia Aquarium*

Traumatic injuries (e.g. boat strikes, shark bites), ingestion of fish hook and line, and entrapment in fishing gear are common in sea turtles that are presented for rehabilitation and often require surgery and pain management. Until recently pharmacokinetic data on sea turtle analgesic drugs were very limited, so dosage regimens were generally extrapolated from other animal species, with consequent risks of clinical failure or harm to the animal. Some recent studies are beginning to unravel the complexities of pain management in sea turtles (Clauss et al. 2007, Lai et al. 2015, Norton et al. 2015). Meloxicam (MLX) is a cyclooxygenase-2 selective Non-Steroidal Anti-inflammatory Drug (NSAID) used extensively as an analgesic agent in humans and companion animals. In all species studied, MLX undergoes extensive hepatic metabolism into inactive metabolites, which are excreted in urine and feces. MLX pharmacokinetics has been reported in loggerhead sea turtles (Clauss et al. 2007, Lai et al. 2015). A dose of MLX at 0.1 – 0.2 mg/kg was used in the loggerhead studies and plasma MLX levels considered to provide analgesia in other species were not achieved and measurable plasma levels were maintained for only a few hours. The purpose of this study was to establish baseline pharmacokinetics of meloxicam after a subcutaneous (SC) dose in 3 species of sea turtles, loggerheads, greens and Kemp's ridleys. One of the main differences among species is the rate of drug transformation. Due to the large degree of variation in metabolism, pharmacokinetic parameters must be established in each species. Plasma MLX concentrations considered to provide analgesia in mammals range from 0.5-1.5 µg/m1. At this time only preliminary data is available on 6 loggerheads, 7 Kemps ridley, and 4 green turtles. At a dose of 2 mg/kg administered SC in loggerheads, plasma MLX peaked at approximately 1 hour and maintained levels above 1 microgram/ml

for approximately 4 hours and then dropped below plasma MLX levels that would be considered analgesic. At a dose of 1 mg/kg MLX SC, Kemps ridleys had peak plasma MLX levels at approximately 15 minutes and maintained plasma levels above 1 microgram/ml for approximately 12 hours and had measurable levels for 48 hours. Most interestingly, green turtles given a dose of MLX of 1 mg/kg SC had peak concentrations at 30-60 min and maintained plasma levels above 1 microgram/ml beyond 72 hours. Samples were only taken out to 72 hours, but will be extended as we move forward with the study.

TOXIC ELEMENTS, HEALTH, AND IMMUNE-RELATED PARAMETERS ASSOCIATED WITH FIBROPAPILLOMATOSIS IN GREEN TURTLES (*CHELONIA MYDAS*) IN WESTERN FLORIDA WATERS

Justin R. Perrault[1], Nicole I. Stacy[2], Cody R. Mott[3], Jonathan C. Gorham[3], Michael J. Bresette[3]

[1]Loggerhead Marinelife Center, Juno Beach, Florida USA
[2]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Florida, Gainesville, Florida, USA
[3]Inwater Research Group Inc., Jensen Beach, Florida USA

The Big Bend area of Florida's gulf coast serves as an important developmental habitat for juvenile green turtles, yet has received relatively little attention in the literature. In this area, we found that up to 80% of green turtles exhibited external tumors consistent with fibropapillomatosis (FP). A number of studies have investigated health parameters and immune responses of marine turtles affected with FP, but no studies have combined a full suite of toxic element analyses, health, and immune-related indices and correlated those with tumor scores. Understanding health and immune responses of green turtles is important, as tumor formation could be a sequela from multiple factors contributing to compromised health. Lastly, the majority of published FP health studies focus on Hawaiian green turtles, leaving the health of Florida FP-infected green turtle populations poorly understood. Using a dip net, we captured and collected blood from 25 juvenile green turtles (SCL_{min} range = 27–43 cm; N = 5 with tumor score 0, N = 8 with tumor score 1, N = 12 with tumor score 2) in Big Bend in June 2015. Plasma samples were analyzed for biochemistry, hematology, protein electrophoresis, activities of catalase, lysozyme, and superoxide dismutase, the presence of reactive oxygen species; red blood cells were analyzed for toxic elements (As, Cd, Pb, Hg, Se, Tl). These parameters were compared to Balazs tumor scores using a Kruskal-Wallis test with a post hoc Dunn's test. There were no differences in SCL_{min}, weight, or body condition index among the turtles with different tumor scores. Iron, glucose, sodium, chloride, osmolality, Cd, and Se were significantly lower in turtles with tumor score 2 compared to tumor-free turtles. Blood urea nitrogen (BUN) was significantly lower in turtles with tumor scores 1 and 2 compared to tumor-free turtles. Decreased iron without a concomitant decrease in plasma proteins can be observed with inflammation, while decreased glucose and BUN suggest reduced feeding; however, 24 of 25 turtles were in good or robust body condition. Although within normal reference ranges, statistically lower sodium, chloride, and osmolality in turtles with tumor score 2 compared to tumor-free turtles may suggest a challenge in osmoregulation. Interestingly, turtles with more tumors concentrated around the eyes had lower, albeit still normal, electrolytes, signifying that the tumors may interfere with salt gland function. It is puzzling that Cd and Se were significantly lower in turtles with tumor score 2 compared with turtles with tumor score 0, since toxic elements have been associated with this disease. However, these results could further indicate decreased feeding, as concentrations of toxic elements in blood are indicative of recent dietary intake. The decreased Se concentrations in tumored turtles are interesting, as Se serves as an antioxidant and perhaps may be utilized to combat oxidative stress associated with FP. The results presented herein are beneficial for rehabilitation facilities, providing information on the overall health of turtles exhibiting a particular tumor

score. We plan to continue sampling in 2017 to increase our sample size so that further trends may be revealed.

HISTOPATHOGICAL EVALUATION AND DETECTION OF CHELONID HERPESVIRUS 5 (ChHV5) IN *CHELONIA MYDAS* WITH AND WITHOUT FIBROPAPILLOMATOSIS CAPTURED IN ALMOFALA-CE, BRAZIL

Roberta Ramblas Zamana[1,2,3], Marco Aurélio Gattamorta[1,4,5], Silmara Rossi[1,5], Gislaine Taimara Dalazen[2,3], Pablo Felipe Cruz Ochoa[1,2,3], Fabiola Eloisa Setim Prioste[1], Eliana Reiko Matushima[1,2,3]

[1]Grupo de Pesquisa sobre Fibropapilomatose em Tartarugas Marinhas. Universidade de São Paulo, Brazil
[2]Programa de Pós-Graduação em Patologia Experimental e Comparada. Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[3]Laboratório de Patologia Comparada de Animais Selvagens (LAPCOM). Departamento de Patologia Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[4]Faculdades Metropolitanas Unidas (FMU), Brazil
[5]Fundação de Estudos e Pesquisas Aquáticas (FUNDESPA), Brazil

Fibropapillomatosis (FP) has multifactorial etiology, in which several biological, genetic and environmental cofactors play a significant role in the pathogenesis in addition to the alphaherpesvirus Chelonid herpesvirus 5 (ChHV5). The Ceará coast of northeastern Brazil extends 573 km along the Equatorial South Atlantic Ocean, and presents the highest Brazilian prevalence of FP (32.59%). Almofala-CE is an area characterized by traditional fishing communities, low industrial development and agricultural lands, and is considered an important feeding area for green sea turtles. In Brazil, many studies have been done in order to elucidate the development of FP and to clarify its physiopathology. The aims of this study were to characterize the tumors and skin by histological analysis and to detect ChHV-5 by molecular tests in green sea turtles with and without FP captured in Almofala-CE. Eight juvenile specimens of *C. mydas* with curved carapace length (CCL) ranging from 34.2 to 49.1cm (40,6±5,9cm), being 3 with FP, were captured incidentally in fishing wear, district of Almofala/CE, and they were delivered to Brazilian Sea Turtles Conservation Program (Projeto TAMAR). Skin (from non-affected by FP) and tumor biopsies were fixed in Bouin solution for histopathology analysis, and stored in RNAlater and frozen at –20 oC until molecular processing. Slides of the tumor samples were stained with Hematoxylin--Eosin (HE). The detection of the presence of ChHV5 were performed by polymerase chain reaction using three sets of oligonucleotide primers designed to target highly conserved markers in ChHV5: GTHV to DNA polymerase (UL30 region – 484 bp), F-US3B to serine-threonine kinase (US3 short region – about 700 bp) and UL18 to capsid protein gene UL18 (140 pb). The presence of one or more amplicons in agarose gel 2% was considered positive to ChHV5. According to histopathological examination, the cutaneous growths corresponded to papillomas (N=2), and fibropapilloma (N=1) according to their epithelial and/or stromal proliferation. Intranuclear inclusion bodies were present in one papilloma. There were not observed histopathological modifications in the skin. We did not detect the ChHV5 in one green sea turtle with FP; on the other hand, five specimens (62.5%) were positive to ChHV5 but only two of them were FP positive, whereas the other three ones had the ChHV5 detected in the skin samples. A large proportion of *C. mydas* non-affected by FP carries ChHV5 presumably through persistent latent infections. Hence, these results support the theory that ChHV5 is a near ubiquitous virus with latency characteristics requiring cofactors, such as environmental pollutants or immune response, to induce FP. These preliminary results point to the importance of long-term studies to understand the prevalence of the ChHV5 and the proportion of FP individuals in mixed stocks in Brazilian Atlantic coast.

ARE "HOOKED" SEA TURTLES A REPRESENTATIVE SAMPLE OF VIRGINIA STRANDINGS?

Sarah A. Rose[1], Kristine M. Williams[1], Molly A. Kolaczek[1], Kathryn J. O'Hara[1], Susan G. Barco[1,2]

[1]Virginia Aquarium & Marine Science Center, 717 General Booth Blvd, Virginia Beach, VA 23451
[2]UNC Wilmington, Dept. of Biology and Marine Biology, 201 S. College Rd, Wilmington, NC 28403

The Virginia Aquarium Stranding Response Program (VAQS) seasonally documents four species of sea turtles. Loggerheads are the most commonly encountered, accounting for 61.7% of reports (n=1171) since 2009. Kemp's ridleys are the second most common species, accounting for 26.1% of reports (n=495). The occurrence of this species has been increasing since the advent of the Virginia Pier Partner Program, an outreach program designed to encourage pier fishers to report live, hooked turtles. As hooked Kemp's ridleys are continuing to drive stranding trends in Virginia, it's important to discern whether these turtles are more representative of typically encountered stranded turtles or wild, apparently healthy turtles. Frequently, admitted hooked turtles are encountered earlier in the season (May-October) than most other strandings, likely representing the time period when turtles are first entering Virginia. Upon admission, many of these animals presented with hypoproteinemia (albumin <1.0g/dL), deemed clinically significant by veterinary staff, resulting in postponed release. Anecdotally, live-captured, or "wild, apparently healthy" Kemp's ridleys captured at the same time for VAQS research projects tended to exhibit similar low albumin values, but this parameter being low was not considered a requirement for rehabilitation under NMFS permit guidelines for live-capture research. A comparison of three major groups of Kemp's ridleys was performed, including "hooked", "wild", and "stranded" turtles. There was no statistical difference between albumin levels in wild caught turtles and hooked turtles ($t=1.1229$, $p=0.31$). When the albumin levels for hooked Kemp's ridleys were analyzed with a Kruskal-Wallis test by the month of the capture, the albumin level was statistically different among the months of capture ($\chi2=21.0563$, $p<0.0001$), and the mean albumin level increased from spring (May & Jun) through summer (Jul-Sep) then began to decrease slightly in the fall (Oct-Nov). A non-parametric Tukey and Kramer post-hoc rank comparison test confirmed that spring was statistically different from summer ($p=0.0001$) but not fall ($p=0.0744$), and fall and summer were not different ($p=0.9955$). Body condition index (BCI) of hooked and stranded turtles were also compared. Using a Wilcoxon rank-sum test, hooked ridleys (n=74) had a significantly higher mean BCI of 1.460 (+0.114 SD), as opposed to stranded ridleys (n=38) which had a mean body condition score of 1.352 (+0.129; $p>0.0001$). The wild group was data deficient for mass and straight carapace length. A Kruskal-Wallis test indicated no effect of month on BCI as a group ($X2=13.454$, $p=0.1431$), or when the two groups were split (hooked, $X2=8.9313$, $p=0.2576$, stranded, $X2=10.23$, $p=0.2493$). Mean albumin levels differed between the hooked (0.8507g/dL) and cold-stunned, stranded turtles (the largest subgroup of stranded turtles) (1.0857g/dL) but was not significant ($W=362.5$, p-value=0.09372). These results challenge the veterinary requirement of a standard minimum albumin value for release. Additionally, hypoproteinemia paired with significantly higher body condition suggests that the hooked turtle group exhibits subtle variation from our knowledge of health parameters from strandings. Due to the variable differences between hooked turtles and stranded turtles, enlarging our "wild" dataset may represent a less biased group of animals, and improve our knowledge of the growing Kemp's ridley population in Virginia.

EVALUATING THE SEVERITY OF FIBROPAPILLOMATOSIS IN *CHELONIA MYDAS* STUDIED IN BRAZIL: A NOVEL PROPOSAL BASED ON AN OBJECTIVE INDEX AND A SCORE SYSTEM

Silmara Rossi[1,2], Angélica María Sánchez-Sarmiento[3], Ralph Eric Thijl Vanstreels[3], Robson Guimarães dos Santos[4], Fabiola Eloisa Setim Prioste[1], Marco Aurélio Gattamorta[1,2,5], José Henrique Hildebrand Grisi-Filho[6], Eliana Reiko Matushima[1,3]

[1]Grupo de Pesquisa sobre Fibropapilomatose em Tartarugas Marinhas, Universidade de São Paulo, Brazil
[2]Fundação de Estudos e Pesquisas Aquáticas (FUNDESPA), Brazil
[3]Laboratório de Patologia Comparada de Animais Selvagens (LAPCOM), Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[4]Instituto de Ciências Biológicas e da Saúde. Universidade Federal de Alagoas, Brazil
[5]Faculdades Metropolitanas Unidas (FMU), Brazil
[6]Laboratório de Epidemiologia e Estatística (LEB). Departamento de Medicina Veterinária Preventiva e Saúde Animal, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil

Fibropapillomatosis (FP) is a neoplastic disease that poses a significant threat to conservation of marine turtles, especially green sea turtles (*Chelonia mydas*). Depending on their quantity, size and anatomical distribution, the FP tumors can interfere with hydrodynamics and the ability to feed. Between 2005 and 2014, 214 juvenile green sea turtles with FP (curved carapace length ranging from 30.5 to 68.5 cm; body mass between 2.6 and 35 kg) were captured or rescued along the coast of five states on the Brazilian coast: São Paulo (n = 72), Rio de Janeiro (n = 1), Espírito Santo (n = 133), Bahia (n = 4) and Ceará (n = 4) according to monitoring of Projeto TAMAR. For each examined specimen, FP tumors were counted and classified according to their size based on Work & Balazs (J. Wildl. Dis. 35:804-807, 1999): A (under 1 cm), B (1-4 cm), C (4-10 cm) and D (over 10 cm) and their anatomical distribution. The aim was to develop a novel method based on an objective index that provides a score system adapted to geographic regions, considering that the patterns in quantity, size and distribution of tumors revealed interesting aspects in the clinical manifestation of FP in specimens studied in Brazil. A total of 7466 tumors were counted, ranging between 1 and 129 tumors per specimen; most tumors were on the limbs, with 45% on the forelimbs and 34% on the hindlimbs. The number of tumors in each size category was then used to calculate FPI for each individual: $FPI = 0.1 \times N_A + 1 \times N_B + 20 \times N_C + 40 \times N_D$. Based on FPI, the Southwest Atlantic Fibropapillomatosis Score (FPS_{SWA}) is proposed, wherein an individual is classified as ‘mild’ (FPI under 40), ‘moderate’ ($40 \leq$ FPI to 120), or ‘severe’ (FPI ≥ 120). This index and the score system can be adapted for other areas and compare the characteristics of the disease across regions. Furthermore, the FPS_{SWA} provides a detailed framework for data collection and analysis of the clinical manifestations of FP, allowing for a classification of FP that tends to be less influenced by observer bias or experience than subjective scores.

STRANDINGS OF SICK JUVENILES OF GREEN TURTLE IN THE NORTHCENTRAL REGION OF CUBA: MANAGEMENT IMPLICATIONS

Andy Russet Rodríguez[1], Eddy Garcia Alonso[2], Julia Azanza-Ricardo[3], Yanet Forneiro Martín-Viaña[2]

[1]Acuario Nacional de Cuba
[2]Empresa Nacional para la Protección de la Flora y la Fauna (ENFF) | Cubanacán | Villa Clara
[3]Instituto Superior de Tecnología y Ciencias Aplicadas

Marine turtles are highly threatened species due to human activity. In last decades it has been an increase in the presence of fibropapillomatosis in these species possibly as a result of pollution. For this reason, Cuba established in 2013 a system of alert to detect ill individuals. In this work we present the results of the examination of green turtle juveniles with fibropapilomas in the Fauna Refuge "Lanzanillo-Pajonal-Fragoso" administrated by the National Enterprise for the Protection of Flora and Fauna in Cuba. So far there are 14 sightings, more frequent in Nasabal bay (eight in total) and the rest in Juan Francisco Bay. From nutritional evaluation it was found that 60 % was severely or lightly starved indicating that the presence of the disease, although not lethal by itself, diminishes performance capacity of sick individuals to develop vital functions especially when they are located in the mouth, eyes, flippers and cloaca. In particular, starved animals had significantly more large tutors than those in good nutritional condition. Finally, the presence of three heavy metal, including mercury was detected in most of the sampled areas indicating this stress factor as the possible cause of the development of the disease. Further studies like in water studies and more sensitive heavy metals analysis are needed to determine the severity of fibropapilomas incidence in this area and determine management measures to be taken at a short and long term.

CO-EVOLUTIONARY DYNAMICS OF IMMUNE GENES AND HERPESVIRUSES IN JUVENILE GREEN AND LOGGERHEAD SEA TURTLES*

Anna Savage[1], Matthew Lawrance[1], Elizabeth Abney[1], Katherine L. Mansfield[1]

[1]University of Central Florida

The tumor disease fibropapillomatosis (FP) is widespread among sea turtles and remains an enigmatic infectious disease with unclear causes and consequences for turtle health and survival. FP causes cutaneous benign tumors in all sea turtle species and is likely caused by a chelonid fibropapilloma-associated herpesvirus (CFPHV) that globally infects juvenile sea turtles. However, definitive links between the virus and FP are lacking, therefore the impacts of CFPHV infection on sea turtle health and immunity are unknown. Here, we investigate the host and pathogen genetic factors influencing sea turtle FP dynamics by sequencing turtle immune genes and CFPHV genes from juvenile green turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) from the Indian River Lagoon system in Florida, USA. Turtle immune genes of the Major Histocompatibility Complex (MHC) code for proteins that identify pathogen molecules and present them to T-cells to initiate acquired immunity. Because higher levels of MHC variation allow more pathogens to be recognized, MHC genes are the most diverse genes in the vertebrate genome, with multiple gene copies and often dozens of genetic variants in a single population. Due to this high variability and important role in immunity, MHC genes are ideal markers for measuring the genetic viability and health of populations, particularly in the context of disease. We sequence a MHC class I gene from CFPHV-

infected *C. mydas* and *C. caretta* individuals with and without FP, as well as three genetically variable CFPHV genes, and conduct co-phylogenetic analyses to test for specific associations between host immune genes and viral strains. We also determine whether FP occurrence is linked to particular turtle MHC variants or viral strains to better resolve the relationship between CFPHV infection and development of FP tumors. Understanding the underlying mechanisms driving disease prevalence within Florida's sea turtle populations is a necessary first step in developing the management and conservation approaches needed to mitigate for disease and to identify better treatment and prevention options.

BLOOD BIOCHEMISTRY VALUES OF LOGGERHEAD TURTLES IN FORAGING, INJURED AND DIFFERENT NESTING POPULATIONS IN THE WESTERN MEDITERRANEAN COAST OF TURKEY*

Doğan Sözbilen[1], Yakup Kaska[1]

[1]*Pamukkale University. Faculty of Arts and Sciences*

Blood biochemistry is an essential tool for diagnosing health status and physical condition of wild animals in different states of their life cycle. These parameters can be altered among populations and sexes. In this study, we analyzed 29 different blood biochemical parameters of loggerhead turtles captured from a foraging area (Dalyan; N: 47), nesting females from two distinct nesting grounds (Dalyan Beach N: 73 and Belek Beach; N: 21) and injured turtles at DEKAMER (N: 31) to have better understanding of wild populations' blood parameters. Results were also compared between age and sex classes for turtles captured from foraging area. The measured parameters were Glucose, Urea, Blood Urea Nitrogen (BUN), Creatinine, Uric Acid, Sodium (Na), Clor (Cl), Potassium (K), Calcium (Ca), Phosphor (P), Magnesium (Mg), Alanine Transferase (ALT), Aspartate Transaminase (AST), Alkaline Phosphatase (ALP), Lactate Dehydrogenase (LDH), Creatine Kinase (CK), CK-MB, Gama Glutamyl Transferase (GGT), Amylase (AMY), Total Protein (TP), Albumin (ALB), Globulin (GLB), Iron (Fe), Triglyceride (TG), Cholesterol (CHO), High Density Lipoprotein (HDL), Low Density Lipoprotein (LDL), Very Low Density Lipoprotein (VLDL) and Haematocrit (Hct). Significant differences were noted for all parameters among different groups except ALP. One of the interesting result was Hct values. All group has similar Hct values but Dalyan nesting females have lowest Hct values in comparison to foraging and Belek nesting females. Glucose, Urea, Creatinine, Uric acid, Na, Cl, ALT, AST, AMY, TP, ALB, Iron levels were highest in injured turtles. In general, lowest blood parameters were found in sub-adult loggerhead turtles in foraging areas. Males have statistically higher Creatinine, Glucose, LDH, HDL, LDL values while females have higher Urea, BUN, TG, VLDL levels. For all other parameters, no statistically significant differences were found between two sexes. The mean cholesterol levels of females at foraging area were even lower than males, but they have two times higher cholesterol levels during nesting. TG and calcium levels showed similar results with cholesterol levels for nesting females. Hct, LDH, Cholesterol, HDL levels showed statistically different results between Dalyan and Belek nesting females. Results of this study have the largest sample size for blood biochemistry of loggerhead turtles in the Mediterranean. Differences between two nesting female populations in a relatively narrow area shows that geographic location can play an important role for blood parameters. Our results show important differences and can be used as reference values for diagnostic use between foraging, nesting, and injured loggerhead turtles for the Mediterranean.

VITELLOGENIN CONCENTRATION IN FORAGING LOGGERHEAD SEA TURTLES

Sydney Stewart[1], Roldán A. Valverde[1], Barbara A. Schroeder[2], Allen M. Foley[3], Blair Witherington[3]

[1]Southeastern Louisiana University
[2]National Oceanic and Atmospheric Administration - National Marine Fisheries Service
[3]Florida Fish and Wildlife Conservation Commission

Sea turtles are capable of producing a large number of eggs every breeding season. Eggs are laid in of two to as many as nine, depending on the species. Although significant progress has been made in our understanding of the physiologic control of the ovary, much remains to be elucidated with regard to key aspects of ovarian recrudescence. The objective of this study was to generate the first pre-nesting vitellogenin (VTG) circulating concentration in sea turtles caught at their foraging ground. We quantified VTG concentration in wild, free-ranging Loggerhead (*Caretta caretta*) captured at the Florida Keys foraging grounds. Loggerheads were captured by hand using the turtle rodeo technique during the month of March over the course of 10 years; a blood sample was drawn from each of 48 females captured this way. Blood samples were processed to plasma and stored frozen until analysis. Plasma was assayed via an in-house ELISA using an antibody specifically generated against Loggerhead VTG. Results showed that 77% of the females had a VTG concentration consistent with a recrudescing ovary. This suggested that the Florida key foraging population contains a large number of animals that may join the breeding population any given year. Our working hypothesis was that VTG may be used as a predictor of nesting numbers in the State of Florida. However, because samples came from different years the sample size for any given year is insufficient to draw a conclusion in this regard. More information is required to understand the control of ovarian recrudescence from the perspective of VTG physiology. The novel information generated by our preliminary study will contribute to fill in the gaps of our knowledge of sea turtle reproductive physiology. Understanding sea turtle reproductive biology can greatly assist conservation organizations by providing them with the knowledge needed to better allocate resources to effectively support their conservation efforts. Our VTG data may also serve to gain an improved understanding of the role of this hepatic protein in the reproductive physiology of sea turtles.

SELENIUM AND ARSENIC BLOOD LEVELS: CASE REPORT IN FOUR SPECIMENS OF *CHELONIA MYDAS* WITH FIBROPAPILLOMATOSIS RECAPTURED IN A FEEDING AREA OF ESPÍRITO SANTO, BRAZIL

Gislaine Taimara Dalazen[1,2], Fabiola Eloisa Setim Prioste[3], Silmara Rossi[3,4], Roberta Ramblas Zamana[1,2,3], Marco Aurélio Gattamorta[3,4,5], Eliana Reiko Matushima[2,3]

[1]Programa de Pós-Graduação em Patologia Experimental e Comparada. Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[2]Laboratório de Patologia Comparada de Animais Selvagens (LAPCOM). Departamento de Patologia, Faculdade de Medicina Veterinária e Zootecnia. Universidade de São Paulo, Brazil
[3]Grupo de Pesquisa sobre Fibropapilomatose em Tartarugas Marinhas. Universidade de São Paulo, Brazil
[4]Fundação de Estudos e Pesquisas Aquáticas (FUNDESPA), Brazil
[5]Faculdades Metropolitanas Unidas (FMU), Brazil

Depending on concentration trace elements may have harmful effects; however, some of them are essential for the biological process and biota. Many routes can introduce these elements into the aquatic environment

and one of them is anthropogenic activity. Green sea turtles (*Chelonia mydas*) have been affected by fibropapillomatosis (FP) that has a multifactorial and complex etiology, and it has been well known that the environmental pollution can play a role in its pathogenesis. In order to study how pollution could be related with FP, the aim of this study was to evaluate the variation in blood concentration of Arsenic (As) and Selenium (Se). Four juvenile green sea turtles with curved carapace length (CCL) ranging from 32 to 49 cm (42±0.06 cm) were studied in the effluent discharge channel of a steel plant in Serra/ES, used by green sea turtles as a feeding area. Captures and recaptures were conducted according to monitoring of Projeto TAMAR in 2013 and 2014. One milliliter of blood of each specimen was collected from cervical venous sinus and stored in Vacuette® Trace Elements Heparin Sodium tubes and maintained at -80 ºC until the analysis. The measure of As and Se was carried out in an Inductively Coupled Plasma Mass Spectrometer (ICP-MS) operating with high-purity argon. The range between capture and recapture varied from three to ten months and the results are presented for As and Se concentrations, and according to capture (A) and recapture (B). Two specimens had decrease of FP tumors and increase of concentrations: one of them presented 244.860 and 273.507 $\mu g.L^{-1}$ for As, 323.841 and 586.157 $\mu g.L^{-1}$ for Se; the other one presented 189.353 and 278.626 $\mu g.L^{-1}$ for As, 349.993 and 465.283 $\mu g.L^{-1}$ for Se. On the other hand, the two other specimens had an increase of FP tumors, and decrease of the studied element concentrations: one of them presented 427.121 and 239.458 $\mu g.L^{-1}$ for As, 587.811 and 423.866 $\mu g.L^{-1}$ for Se; the other one presented 12.200.632 and 1.466.847 $\mu g.L^{-1}$ for As; and 6.847.749 and 627.124 $\mu g.L^{-1}$ for Se. Although the specimens that presented a decrease of FP tumors, when recaptured, had an increase of concentrations, the higher concentrations were observed in the green sea turtles with an increase of FP tumors. Studies have revealed that there is some relation between As and Se suggesting a protector effect from As in the toxicity of Se, or a low concentration of Se can decrease the toxicity of As. Even though the number of studied green sea turtles had been small, the presented data can be evidence about the relation between As and Se, and the clinical manifestation of FP. However, more studies should be conducted in order to clarify the link between FP and these elements, which can bring knowledge for sea turtle conservation.

INFLUENCE OF INCUBATION TEMPERATURE PARAMETERS ON LOGGERHEAD HATCHLINGS FITNESS AND GROWTH RATE

Alejandro Usategui-Martín[1,2,4], Patricia Ostiategui-Francia[2], Daniel Montero Vítores[1], Valentín Pérez Mellado[3], Ana Liria-Loza[3]

[1]*University of Las Palmas de Gran Canaria (ULPGC)*
[2]*EcoAqua institute*
[3]*ADSbiodiversidad*

Natural sea turtles' nests present a complex temperature pattern along incubation period due to the influence of a large number of environmental factors (rain, tides, clay presence, vegetation, predation, etc.). On the other hand, the nest itself generates heat due to the embryo's development, so the incubation temperature pattern is always variable. However, in many studies, where nest required to be incubated artificially, stoves are set up at a constant temperature all along their incubation to eliminate possible effects of other variables in the study. But nothing is known about the effect of variable / stable incubation temperature on hatchlings' fitness. The goal of this experiment was to determine if natural nest temperature pattern affects hatchlings size, survival or growth rate. To assess it, different clutches were collected from Cape Verdeans beaches and were placed during all incubation period in stoves arranged with different temperature patterns, one with stable temperature (30.5ºC) and other with variable temperature (30.0 to 33.0ºC) -trying to imitate the natural temperature fluctuation-. Each nest was divided between both stoves to eliminate the maternal influence. Biometrics of all individuals were taken at hatch. Hatchlings were reared in captivity during 4 months and biometry was measured each week. Results endorse that there are

no significant differences between hatchlings coming from stable or variable temperature stoves, so it is not necessary to imitate the natural incubation pattern in artificial incubation experiments. Also, differences in males and females' fitness –produced in stoves at high (31.0ºC and 30.5 to 32.0º) and low (27.0ºC and 26.5 to 28.5ºC) temperatures- have been studied. Our investigation confirms that males are bigger than females, but only at hatch moment, because during the first week of life they come to switch their sizes, and females get bigger than males due to their higher growth rate.

THE EFFECT OF ESTRADIOL ON THE OVARIAN DIFFERENTIATION OF MARINE TURTLE *LEPIDOCHELYS OLIVACEA**

Alma Guadalupe Vazquez Gomez[1], Horacio Merchant-Larios[2], Alejandro Marmolejo-Valencia[2], Verónica Díaz Hernández[1]

[1]Departamento de Embriología. Facultad de Medicina. Posgrado en Ciencias del Mar y Limnologí-a. Universidad Nacional Autonoma de México
[2]Departamento de Biologí-a Celular y Fisiologí-a. Instituto de Investigaciones Biomédicas. Universidad Nacional Autonoma de México

Temperature Sex Determination (TSD), among turtles shows that Sox9 gene expression maintains gonads of incubated embryos at male-promoting temperature (MPT). Contrastingly, when embryos are incubated at female-promoting temperature (FPT), aromatase expression and estrogens are involved in ovary differentiation. However, little progress has been made in establishing the role of estrogen in the development and differentiation of the ovary among species manifesting TSD. This study aims to determine the role of estrogen in ovarian differentiation, considering two histological contexts: the reorganization of the medullar region and the thickening of the cortical region. We collected biological material with permission number: SEMARNAT PAGM/DGVS703109715. Subsequently we examined the effect of estradiol by treating Lepidochelys olivacea embryos incubated at TF and TM, with 12µg of 17β-estradiol and two estrogen inhibitors: fadrozole (200µg) and fulvestrant (50 µg). The effect of estradiol on ovarian differentiation was evaluated in histological sections of gonads. Gonads from embryos incubated at TF showing a thick cortex formed by several layers of epithelial cells (CK+) and the medullar cords were fragmented with Sox9 negative. Likewise, the gonad incubated at TM showed a single surface epithelium and medullar cords with Sox9 positive and abundant stromal tissue. Gonads subjected to estradiol treatment and incubated at TM are presented as small gonads with reduced and fragmented medullar cords that are positive to Sox9 and ovarian cortex. At TF, gonads showed reduced fragmented medullar cords and ovarian cortex. In embryos incubated at TM and treated with fadrozole or fulvestrant, gonads manifested characteristics related to testes (positive Sox9). However, at TF and treated with fadrozole or fulvestrant, gonads showed ovarian cortex with permanent medullar cords, but these were negative to Sox9. We conclude that estrogens are involved in remodeling the medullar region of the ovary. However, they do not appear to influence the development of the cortical region of *Lepidochelys olivacea* gonads. This kind of study provides information that reveals the environmental problem to which sea turtles are exposed: an excessive increase in estrogens on beaches, coming from residues like PET. This may be intervening in the teratogenic effect of *Lepidochelys olivacea* on the nesting beaches, thus, endangering the species.

MEASUREMENT OF MONOESTER PHTHALATE METABOLITES AS MARKERS OF PHTHALATE CONTAMINATION IN EGGS OF *DERMOCHELYS CORIACEA* AND *CARETTA CARETTA**

Javier Velasco[1], Curtis Hedman[2], Warren Porter[1], Roberta Dollinger[1], Alissa Lenz[1]

[1]*University of Wisconsin-Madison*
[2]*Wisconsin State Laboratory of Hygiene*

Here we present a new method of analysis of phthalate metabolites in sea turtle eggs. Phthalates are environmental pollutants that are known endocrine disruptors and long-term exposure can adversely affect reproduction. Phthalates are used as plasticizers in the manufacture of polyvinyl-chloride (PVC) plastics and are not chemically bonded therefore they are easily released into the environment. Phthalates have become increasingly problematic since plastic garbage is ubiquitous in the world's oceans and constitutes upwards of 86% of oceanic debris. Sea turtles ingest plastic as they confuse them with their normal food. Leatherback (DC) and loggerhead (CC) spend time in the oceanic convergence zones that concentrate marine debris, thus leading to a potentially large consumption of plastics. Little is known about their toxic load and effects on the overall health. The transfer of organic pollutants from the mother to eggs in has been previously documented and phthalates are expected to follow this pathway. Phthalates are not reliable indicators of marine pollution due to their short half-life via metabolism into the monoester metabolites. This metabolism is documented in mammals and follows two steps: (I) the hydrolysis to monoester phthalate, (II) conjugation via glucuronidation or sulfation. Therefore, to be able to identify their presence we developed a method in which we removed the conjugate utilizing β-Glucuronidase/Arylsulfatase and tested for the metabolites via liquid chromatography/tandem mass spectrometry (LCMSMS). We analyzed samples for 4 monoester phthalate: Mono-2-ethylhexl phthalate (MEHP), Mono-benzyl phthalate (MBzP), Mono-ethyl phthalate (MEP) and Mono-n-butyl phthalate (MnBP). In brief, 10 specimens for each species were defrosted, removed from the shell and placed in a clean 250 mL beaker. Samples were homogenized in dry ice until the consistency of a light powder. The dry ice was allowed to sublimate at -20 °C. 10 uL Beta Glucuronidase/Sulfatase 100,000 units/mL was added and buffered (Na Acetate buffer pH 7.5 1.0 M) and incubated at 37 °C overnight. pH was adjusted to 5.5 and incubated again for 24 hrs. Samples were then prepped X3 by adding 5mL ACN, sonicated (10 min), vortexed and centrifuged at 2000rpm (5 min). ACN supernatant was separated and concentrated under nitrogen. Samples were reconstituted with 0.5mL of 2% H3P04 and extracted using a solid phase extraction (SPE) prepped with, 3mL MeOH, 3mL 18-Mohm/cm water and 3mL 2%-H3P04. SPE cartridges were eluted with 3mL MeOH and 3mL MeOH:ACN (1:1) with 1%-HAC and concentrated under nitrogen prior to analysis. Analysis was performed on an Agilent HPLC 1100 (Column Zorbax SB-C18-Rapid Resolution Cartridge 2.1x30mm 3.5 Micron) and a SciX API4000 LCMSMS-Negative APCI. Mobile phase was 10 mM NH4 Acetate and 1:1 Acetonitrile:MeOH.

STRESS RESPONSE OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ENTRAINED IN THE ST. LUCIE NUCLEAR PLANT, HUTCHINSON ISLAND, FLORIDA*

Martha Villalba[1], Roldán A. Valverde[1], Michael J. Bresette[2]

[1]*Southeastern Louisiana University*|
[2]*Inwater Research Group*

Sea turtles show elevated concentrations of corticosterone in response to stress. Corticosterone is a steroid hormone produced by the HPA axis. The beaches in southeast Florida are prolific nesting areas for many sea turtle species, including the loggerhead sea turtle (*Caretta caretta*), with South Hutchinson Island being a critically important nesting beach. The St. Lucie Nuclear Power Plant is located on the east coast of Hutchinson Island and uses nearshore ocean water to cool its reactants. Oftentimes, sea turtles enter the intake structures with the cooling water into a canal system where they must be manually captured and returned to the ocean. In sea turtles, stress has been measured in response to a variety of stressors but never in response to entrainment in the intake structures of a nuclear plant. Two plasma samples were collected at two different time points from 60 loggerhead sea turtles entrained in the intake canal at the St. Lucie Power Plant and 30 additional samples were taken from nesting loggerheads as a reference. Samples were analyzed using a commercial enzyme-linked immunosorbent assay (ELISA) to determine corticosterone concentration. Data show that on average, nesting loggerhead sea turtles had the lowest concentration of corticosterone, the plasma samples taken at the first time point from the turtles from the intake canal had slightly higher corticosterone concentration, and samples from the second time point had the highest corticosterone concentration. A caveat is that we do not know how long entrained turtles spend in the intake canal before retrieving them for study. Preliminarily, we assumed that this time was trivial, especially since their corticosterone concentration was only slightly higher than that measured in nesting animals. Thus, taken together our data suggests that Loggerheads entrained in intake pipes exhibit a moderate adrenal response to stress relative to nesting turtles. Additionally, turtles retrieved from the intake canal were capable of responding to handling stress with higher corticosterone output, indicating that their HPA axis is competent after the animals were retrieved.

MANAGING LONG-TERM WELLNESS IN CAPTIVE SEA TURTLES

Lawrence Wood[1,2]

[1]*Florida Hawksbill Project*
[2]*National Save The Sea Turtle Foundation*

Circumstances surrounding advances in stranding response and veterinary care have created a growing need for the long-term housing of captive sea turtles. However, the difficulty in re-creating natural conditions in captive settings places a responsibility on caregivers to offset wild-type behavioral deficits with enrichment programming that is, preferably, commensurate with the limitations of each enclosure. Though standardized, multi-institutional behavioral monitoring programs are currently lacking for marine turtles, facilities housing (or planning to house) sea turtles for the long-term are strongly advised to include 'wellness' as a fundamental part of their animal care protocol. Here, concepts of wellness and enrichment in sea turtles are reviewed, and a framework for developing long-term behavioral monitoring programming is provided.

BASELINE BLOOD BIOCHEMICAL VALUES FOR THE NORTHWEST ATLANTIC POPULATION OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*)

Tiffany Yang[1], Heather Haas[2], Ronald Smolowitz[3], Samir H. Patel[3], Amanda S. Williard[4,5]

[1]*University of North Carolina Wilmington*
[2]*NOAA NEFSC*
[3]*Coonamessett Farm Foundation*
[4]*Department of Fisheries and Oceans Canada*
[5]*University of North Carolina Wilmington*

Establishing baseline blood chemistry values for healthy, pelagic, wild loggerhead turtles (*Caretta caretta*) provides critical information that can be utilized to assess the health of turtles that have been impacted by natural and anthropogenic means. We analyzed blood samples collected from loggerhead turtles captured offshore in the Mid-Atlantic in 2011, 2012, and 2016 as a part of an on-going satellite telemetry research project. Turtles tracked for a minimum of 3 months post-release were designated "healthy" and included in our analyses. Various blood parameters were determined using both a point-of-care analyzer, the iStat Portable Clinical Analyzer (CG4+, CG8+, or CHEM8+ cartridges), and a veterinary diagnostic laboratory service (IDEXX). Blood variables of interest were packed cell volume, blood respiratory gases, pH, ions, proteins, glucose, lactate, and blood urea nitrogen. Morphometric and environmental factors, such as carapace length and temperature, were included as explanatory variables in models to assess natural variation in blood chemistry for loggerhead turtles from this region. Data were compared to published values for loggerhead turtles from other regions. Our assessment of the natural variation of blood chemistry for loggerhead turtles in the Northwest Atlantic provides a baseline for comparisons with data collected from turtles exposed to potential environmental stressors.

Conservation, Management and Policy

EIGHTEEN YEARS OF SEA TURTLE MONITORING ALONG THE COASTLINE OF CAMEROON, WEST-AFRICA

Isidore Ayissi[1]

[1]*Département d'Océanographie et Limnologie, The University of Douala*

The sea turtle conservation program in Cameroon is relatively recent. Jacques Fretey initiated it following the Ekwata resolution in 1997 and the Abidjan Memorandum in 1999. In the context of Central Africa, Cameroon program is one of the oldest sea turtle conservation with 18 years of monitoring and surveys (1999-2016). Most of the beaches monitored are located in the southern part of the Cameroon coastline (in the vicinity of the town of Kribi in the Region of the South). The general objective of the sea turtle program in Cameroon is the protection of the sea turtles as well as their natural habitats. The program includes (1) Monitoring of the sea turtle nesting on the sandy beaches and of sea turtle feeding in the coastal waters of Cameroon, (2) Screening of the coastline in order to map and characterize the sea turtle nesting and feeding habitats, (3) Assessment of the human impacts on these endangered species protected by national laws, (4) Promotion of the Marine Protected Area including the sea turtle home ranges, (5) Support to conservation actions by creating alternative income generating activities (AIGA). Four species of sea turtle are occurring in Cameroon, by order of decreasing frequencies: the green turtle (*Chelonia mydas*), the olive ridley turtle (*Lepidochelys olivacea*), the leatherback turtle (*Dermochelys coriacea*), the hawksbill turtle *(Eretmochelys imbricata*). The olive ridley and leatherback turtles are nesting on a regular basis on the sandy beaches of Cameroon from September to March. The Green and Hawksbill turtles, mostly juveniles and sub-adults are feeding on rocky sea grounds and seagrass in the nearshore shallow waters along the Cameroon coastline. Some green turtle nesting is also recorded along the coastline. These four species are facing several threats, which are by decreasing order of impact: (1) Poaching of female and illegal harvesting of nets. (2) By-catch and intentional catches mainly in artisanal dormant gillnets as well as by catches by industrial trawlers (3) Disturbances, degradation and destruction of coastal habitat (nesting and feeding areas) due to urban and industrial development (oil platform, deep sea port, power facilities, etc. leading to loss of habitats, increased light pollution and erosion) (4) Coastal waters pollution and coastal fringe pollution due to agro-industries, oil industries, poor waste management, etc. The monitoring along 18 years allows for determining the trend of the nesting activities in Cameroon for the two main nesting species: Olive ridley and Leatherback turtles. These trends are presented and discussed in comparison with the sub regional trends observed at the scale of Central Africa. In order to safeguard of the sea turtle species in Cameroun on the long term, the Cameroon's NGOs now implement their actions in the larger framework of Rastoma, the Central African Network of the Sea Turtle Conservation Actors (www.rastoma.org).

TURBINES AND TURTLES: APPLIED SCIENCE FOR RESPONSIBLE OFFSHORE WIND DEVELOPMENT IN THE U.S. ATLANTIC

Kyle Baker[1]

[1]*Bureau of Ocean Energy Management, Office of Renewable Energy Programs, USA*

The Bureau of Ocean Energy Management (BOEM) is the U.S. agency responsible for offshore wind energy development on the U.S. Outer Continental Shelf. Offshore wind facilities are anticipated to benefit

sea turtles by offsetting greenhouse gas emissions, but could be constructed in migratory and foraging habitats for sea turtles along the U.S. Atlantic coast. BOEM is ensuring the development of offshore wind energy is informed by the best available science to minimize impacts to threatened and endangered sea turtles. BOEM's Office of Renewable Energy Programs is engaged in a number of applied research efforts that are collectively providing new information on sea turtles and the potential environmental effects from offshore wind activities. The Atlantic Marine Assessment Program for Protected Species is an ongoing collaborative effort of BOEM, NOAA Fisheries, the U.S. Fish and Wildlife Service, and U.S. Navy to collect information about the seasonal abundance, health, and habitat use of sea turtles in the U.S. Atlantic. To improve regional abundance estimates, BOEM has supported the tagging and biological sampling of loggerhead sea turtles. Behavioral information from sea turtles will provide a better understanding of the movements, surfacing patterns, diet, and health status of sea turtles. In addition to broad scale surveys in the Atlantic, fine-scale surveys are also being conducted within offshore wind energy areas. Sea turtle surveys were conducted from 2013 to 2015 in wind energy areas off Massachusetts and Rhode Island through a collaboratively funded effort between BOEM and the Massachusetts Clean Energy Center. The aerial survey effort over three years showed leatherbacks are the most sighted turtle in the northeast wind energy areas during the summer and fall. A "hot spot" clustering of leatherbacks occurred each survey year in an area south of Nantucket, an island off the coast of Massachusetts. Loggerhead and Kemp's ridley sea turtle sightings also occurred, but at lower rates than leatherbacks. In addition to studying the abundance and habitat use of sea turtles, BOEM's Real-time Opportunity for Development Environmental Observations (RODEO) allows for opportunistic and real-time observations during the construction and initial operation of wind facilities and conducts studies to aid in the assessment of impacts to sea turtles and habitats. For example, RODEO measured the turbidity during the construction of the power transmission cable effects of cable installation turbidity and seabed recovery associated with burial of the subsea power cable, and pile driving noise during the construction of Deepwater Wind's Block Island Wind Farm offshore Rhode Island. BOEM has also studied the low-frequency hearing ability of leatherback sea turtles by recording auditory evoked potentials of hatchlings in air and underwater. This information will be used to inform environmental assessments regarding the potential effects on the hearing of leatherbacks and types of sounds that may change their behavior during the construction, operation, and decommissioning of offshore wind facilities. The collective results of these and other BOEM-sponsored studies are providing new data on sea turtles and will continue to be applied to assessments of the potential impacts from the construction of wind facilities.

TOWARDS A NATIONAL STRANDING NETWORK: STRANDINGS, INJURIES AND CAUSE OF MORTALITIES

Eyup Başkale[1], Yusuf Katılmış[1], Musa Azmaz[1], Doğan Sözbilen[1], Yakup Kaska[1]

[1]*Pamukkale University*

Turkey has a 2,500 km long coastline and sea turtle nesting activities are seen in the Mediterranean coast of Turkey but sea turtles are being encountered in both Aegean and Mediterranean coasts. Additionally, there are a few records from the Marmara and Black Sea region for loggerhead and green turtles in recent years but most of these records are stranding reports. In this study, we aimed to investigate stranding reports from 2008 to 2016. Stranding reports were gathered from our direct observations, sea turtle conservation and monitoring project reports, unpublished reports of NGOs and the news from the media. We obtained a total of 377 stranding records, of which 288 of them are from our direct observations, sea turtle conservation and monitoring project reports, unpublished reports from local NGOs and 149 of them have appeared in the media. The number of stranding reports increased dramatically in the last 4 years after we established a national stranding network among coast guard command, local NGO's, municipalities and ministerial

provincial offices. In the first 5 years' period of our study, the mean annual stranding reports were 19.2 (range: 7-35) while the mean annual stranding reports were 70.3 (range: 47-114) reached in recent years due to recording of strandings more efficiently. The majority of the stranded turtles were found in Muğla (59.7%) and Antalya (14.3%). The majority (82.5%) of stranding information were given as loggerhead turtles, while green turtles constituted 17.5% which is consistent with the Mediterranean population of both species. The majority of the stranded turtles are female (50.9% for female loggerhead and 9.2% green turtle). Male turtles came second while sub-adult and juvenile turtles came in third place (25.0% for male loggerhead and 3.9% for green turtles; 6.6% for sub-adult and juvenile loggerhead and 4.4% for green turtles). Main injury and death causes were fisheries related problems such as net entanglement and intentional killings (51%) and collusions with sea vehicles (19%). Also, natural problems such as parasite infection, cold stunning take a big proportion with 26%. Stranding reports were mostly coming from Muğla and Antalya provinces where there is a high level of public awareness about sea turtles and most of our volunteer stranding network members located. Also, these two provinces have most of the tourism facilities in the western Mediterranean coasts of Turkey and they have crowded beaches which increases the chance of encountering stranded turtles. Previous studies show that the mean annual stranding numbers were given 26.2 and 12.2 for loggerhead and green turtles respectively but these results cover the years between 2002-2009 in eastern coasts and these results were based on researchers' own observation. Increasing the effectiveness of networking showed that more than 100 sea turtles stranding were encountered in the western coasts of Turkey (114 strandings in 2016). This number may reach to 150 loggerhead turtles and 50 green turtles when we consider the stranding reports from eastern Mediterranean and it can be considered that sea turtle injuries caused by anthropogenic activities are the main problem on sea turtles in Turkey.

COLLECTIVE ACTIONS FOR IMPROVING THE CONSERVATION STATUS OF THE EU SEA TURTLE POPULATIONS - LIFE EUROTURTLES

Paolo Casale[1]

[1]*University of Rome "La Sapienza", Italy*

Nesting sites and foraging grounds located within the European Union member states are extremely important for the Mediterranean sea turtle populations of loggerhead turtles (*Caretta caretta*) and green turtles (*Chelonia mydas*). However, anthropogenic threats are also particularly high in these EU member states where high coastal development and intense fishing activities combine to affect sea turtles at all stages of life, including both terrestrial and marine habitats. The aim of the LIFE EUROTURTLES project is to improve the conservation status of EU populations of two priority sea turtle species, the loggerhead turtle and the green turtle. The project focuses on those areas where conservation measures are considered important and urgent, and could influence sea turtle populations at EU, national and local levels. The project includes six EU countries: Croatia, Cyprus, Greece, Italy, Malta and Slovenia. The specific project objectives are to: (i) reduce the impact of anthropogenic threats at nesting sites; (ii) reduce the impact of anthropogenic threats, in particular fishery-related threats, in foraging grounds; (iii) improve the effectiveness of marine Natura 2000 sites for sea turtle conservation by extending current sites over turtle hot spot areas and improving management; (iv) set up a consistent approach to the conservation of the EU sea turtle populations in order to optimise current and future efforts and resources in the EU; (v) contribute to the EU Marine Strategy Framework Directive with consistent methods and with baseline data for improving the capacity of monitoring the conservation status of the EU sea turtle populations in the future; (vi) promote among EU citizens the concept of a shared responsibility for EU sea turtle populations and the value of natural marine resources of which sea turtles are viewed as an excellent and charismatic flagship species; (vii) set up an EU network for sea turtle conservation based on common objectives and methods.

MANAGEMENT STRATEGIES AT BUCK ISLAND REEF NATIONAL MONUMENT: PROGRAM OVERVIEW AND ADAPTATIONS

Tessa Code[1], Clayton Pollock[1]

[1]*National Park Service*

For almost 30 years, the Buck Island Sea Turtle Research Program has conducted research and monitoring on threatened and endangered sea turtles in St Croix, US Virgin Islands. In an effort to better manage these species, the National Park Service (NPS) is evaluating our current management practices with particular emphasis on emerging challenges such as global climate change and sea level rise, balancing the need for increased effort with fiscal constraints, and the incorporation of new technologies and monitoring techniques into population assessments. In part, this evaluation is driven by the overall success of the program, which has seen a dramatic increase of nesting *Chelonia mydas* and *Eretmochelys imbricata* since 1988 but paradoxically a downward trend in the number of *E. imbricata* over the last 10 years. In addition to presenting hypotheses about this recent trend and its implications, this program review will also discuss 1) linkages between dynamic erosion patterns, nesting density, imperiled nests, and entanglement risks, 2) ways the NPS is working to improve efficiency through collaboration, volunteers, and analyses of nesting activity peaks and cycles to inform effort, 3) how the NPS is utilizing satellite and acoustic telemetry to better understand connectivity between nesting beaches and foraging grounds, and 4) the use of capture-mark-recapture studies to better assess juvenile sea turtle population trends.

INFORMING MPAS AND GEAR MODIFICATIONS FOR A THREATENED CENTRAL WEST AFRICAN SEA TURTLE SPECIES USING SATELLITE TRACKING*

Tiffany Dawson[1], Pierre Didier Agamboue[2], Georges Mba Asseko[3], Francois Boussamba[4], Phil Doherty[5], J. Michael Fay[3], Angela Formia[2], Brendan J. Godley[5], Carmen Karen Kouerey Oliwina[2], Francis Lambert[3], Brice Didier Koumba Mabert[6], Jean Churley Manfoumbi[7], Kristian Metcalfe[5], Ivan Ndanga[2], Jacob Nzegoue[2], Philippe Du Plessis[8], Guy Philippe Sounguet[9], Matthew J. Witt[5], Sara Maxwell[1]

[1]*Old Dominion University*
[2]*Wildlife Conservation Society, Gabon*
[3]*Agence Nationale des Peches et de l'Aquaculture, Gabon*
[4]*Aventures Sans Frontieres, Gabon*
[5]*University of Exeter, Cornwall*
[6]*Centre Nationale des Donnees et des Informations Oceanographques, Gabon*
[7]*Ibonga-ACPE-Gabon*
[8]*Foundation Liambissi, Gabon*
[9]*Aventures Sans Frontieres*

Understanding the horizontal and vertical habitat of olive ridley sea turtles (*Lepidochelys olivacea*), a threatened species, is critical both for determining regions of protection and gear modifications that may effectively reduce bycatch, the largest threat to this species. Argos satellite telemetry transmitters were used to determine movement and dive behavior of 20 female olive ridleys tagged in Pongara National Park, Gabon, Africa. A switching state space model was used to filter the tracking data and categorize the internesting and post-nesting movements. Gridded utilization distribution (UD) home range analysis

conducted using the tracking data revealed that the majority of core habitat occurs in the Gabon Estuary during the internesting period and overlaps with an important artisanal fishing region and high commercial shipping traffic. Only 79% of the 50% UD was encompassed in the current artisanal fishing closure, and 58% of the 50% UD was found in major shipping lanes. Dive data from the 2015 tagging season revealed that during the nesting period, turtles spent the majority of their time resting on the sea bottom of the estuary (75% of dives were between 1-15 meters), however during migration and subsequent foraging in Gabonese waters and beyond, dives were primarily mid-water (82% of dives were between 1-50 meters and 90% of dives were between 1-100 meters). Further, dive data revealed that mid-water fisheries such as trawling may pose the greatest risk during migration and foraging, however, bottom set gear during the internesting period may pose the greatest potential for interactions. National parks currently protect the beach nesting sites but the creation of marine protected areas is also underway; this study quantifies information that the Government of Gabon can use in designing marine protected areas or fishing restrictions. Shared use of the estuary by fisheries and olive ridley sea turtles creates a need for area restrictions.

IMPROVEMENTS AND ADVANCES IN CONSERVATION OF *CHELONIA MYDAS* NESTING BEACHES ON ANDERSEN AIR FORCE BASE, GUAM*

Jessica DeBlieck[1], MaryLou Staman[1], Joshua J. Salas[1], Jennifer Horeg[2], Terry J. Donaldson[1]

[1]*University of Guam*
[2]*Andersen Air Force Base*

The beaches and nearshore water of Andersen Air Force Base (AAFB), Guam provide habitat to green sea turtles (*Chelonia mydas*) and hawksbill sea turtles (*Eremochelys imbricata*), although only green sea turtles have been documented nesting on AAFB. Historical monitoring and protection efforts on AAFB nesting beaches have been inconsistent until 2013, when AAFB and the University of Guam entered a collaborative agreement to improve survey methods and implement more stringent conservation management policies. Utilizing daily nesting beach surveys, game camera monitoring, night surveys, and nest inventories, we identified existing threats to sea turtle nesting and hatchling success. Consistent monitoring and active threat mitigation has, for the first time on Guam, allowed for thorough assessment of multi-year nesting habits and establishment of baseline data for future conservation efforts. Here, we present improvements and advances in conservation of sea turtles and proactive mitigation techniques on Andersen Air Force Base, Guam.

FIRST STEPS TOWARDS INCLUDING SEA TURTLE RESEARCH IN EXTRACTIVE MARINE RESERVE OF SOURCE MANAGEMENT PLAN*

Beatriz Dias[1,2], Bruna Maria Lima Martins[3], Maura Elisabeth Moraes de Sousa[2,4], Andrei Tiego Cunha Cardoso[5], Adrian Jordaan[1]

[1]University of Massachusetts Amherst, Amherst, MA 01003-9285, USA
[2]CAPES Foundation, Ministry of Education of Brazil, Brasa-lia-DF, 70040-020, Brazil
[3]Universidade Estadual de Santa Cruz - UESC, Salobrinho, 45662-900, BA, Brazil
[4]Universidade Federal do Pará - UFPA, Aldeia, 68600-000 BraganÇa, PA, Brazil
[5]ICMBIO - Chico Mendes Biodiversity Conservation Institute, Marajo, Brazil

The State of Para, located in the Brazilian Amazon, is known for its unique environment, and high biodiversity. With the largest continuous mangrove strip in the world (from Para to Maranhao), the region has more than half of all marine protected areas in Brazil. It also represents 20% of Brazilian marine and estuarine fisheries, where 93% of these are classified as artisanal. Extractive reserves were implemented to foster conservation practices and to support small-scale economic activities, allowing the subsistence of local communities. The Marine Extractive Reserve of Soure (RESEX Marinha de Soure) is found among the multi-use conservation areas in the state. Currently, there is the effort from the part of ICMBio/MMA (Chico Mendes institute for Biodiversity Conservation/Brazilian Environment Ministry) to develop and apply the RESEX management plan. However, lack of knowledge about RESEX's role and the status of species of concern has caused a series of conflicts among stakeholders. Despite conservation projects in the region, there is an information gap when it comes to prioritizing actions and efforts. Here we present information regarding species of interest and contrast it with economic activities led on the protected area. We use ArcGIS (10.4.1) to map all the activities occurring in the area. Our data collection encompassed geographic data from ICMbio, IBGE, species of concern data from IBGE, and a 2014 scientific expedition where we mapped the occurrence of sea turtles, dolphins and suitable habitat for manatees, based on grazing spots. The scientific expedition consisted of four days of beach monitoring during the wet to dry season transition. The study area was 60 km of beach, from the Amoroso Cape, located in the northern portion of the island, to the Ceu community. We encountered four river dolphin carcasses (Sotalia fluviatilis) and two Lepidochelys olivacea nests. In addition, we collected and analyzed vegetation samples (Hippocratea volugilis L., Polyphylla Benth, Machaerium Lunaturs (L.F.) Ducko, Avicenia germinans (L.)L., Laguncularia racemosa (L.)CF Gaertn., Crenea maritima Aubl) from the main tidal channels to identify manatee (Trichechus manatus) habitat suitability. We would like to highlight that this is the first sea turtle nesting activity documented on Northeast Marajo Island coast. As a result, we observed the species of concern observations and the overlapping economic activities such as livestock raising, legal artisanal fishing, and illegal fishing. Regarding the livestock activities, the dimensions of farmland overlap the limits of the conservation area; water buffaloes are free-range and are often spotted at the beach. This work is the first mapping exercise considering species of concern at the RESEX Marinha de Soure, providing an understanding of coastal land uses and is a basis for the development of future work at the protected area.

SEA TURTLE – HUMAN INTERACTION TRENDS IN AKUMAL

Darby Gaffney[1], Timothy Gaffney[1], Katherine Comer-Santos[2]

[1]San Marcos High School, San Marcos CA.
[2]Science Exchange

At Akumal, Quintana Roo, Mexico tourists can swim with sea turtles in a protected shallow bay where juvenile green turtles (Chelonia mydas) gather to forage on sea grasses. Our study aimed to determine if the local non-profit group Centro Ecologico de Akumal's (CEA) efforts to educate the public on sea turtle conservation and safe swimming distances from turtles have corresponded with an evident increase in awareness. The reason is that harassment can stress turtles and alter their behavior. Our three week study in July and August of 2016 repeated research by two other Science Exchange interns in 2009 and 2010. We collected data by taking photographs while snorkeling in the water and conducting interviews of visitors on the beach in English and Spanish. Using our underwater photos, we measured approximate distances from the closest part of the tourist to the turtle taking into account the mean length of turtles reported by CEA (50 cm straight carapace length). In the period from 2009 to 2016, the average observed distance of swimmers from sea turtles decreased significantly from a mean of 0.94 m to 0.58 m (students' T test; $p<.05$) – this well beyond the CEA-recommended safe distance of 2 meters. Conversely, the percent of swimmers observed touching the turtles showed a slight decrease from 7% to 5%. We noted that the common factors in swimmers touching the turtles were a lack of a life vest (allowing the swimmer to pursue the turtle below the surface) and an absence of a professional snorkeling guide. No tourist groups with a guide were observed touching turtles. In 2016 we interviewed 138 randomly selected beach visitors. The majority were US, UK, and Mexican tourists, predominantly from 20 to 40 years old. The data were compared with 234 interviews using identical questions in 2009 and in 2010. Results show an increased number of visitors expecting to see a turtle in Akumal over the last six years from 75 to 85%. This was matched with an increase in understanding of the cultural importance of the turtle to the indigenous Mayans (from 24 to 75%) and turtles' protected status in Mexico (from 62 to 77%). We recommend more beach signage using pictographs and training for snorkel guides.

RASTOMA: WORKING TOGETHER TO PROTECT SEA TURTLES IN CENTRAL AFRICA*

Alexis Guilleux[1], Alexandre Girard[1], Isidore Ayissi[1], Samuel Mbungu Ndamba[1], Rodrigue Ngafack[1], Roland Missilou Boukaka[1]

[1]Rastoma

Five of the world's seven sea turtle species are known to occur along coastlines of Central Africa: leatherback, olive ridley, hawksbill, loggerhead and green turtles. All of these species are facing several manmade threats such as nesting female poaching, egg harvesting, fisheries by-catch, habitat loss, ocean pollution and climate change. Rastoma, the Central African network for sea turtles actors, has been created in 2012 in Congo Brazzaville and currently includes nine NGOs covering the six countries of Central Africa with a coast on the Atlantic Ocean: Democratic Republic of the Congo, Republic of the Congo, Gabon, Equatorial Guinea (including Bioko island), Sao Tome and Principe, and Cameroun. Gathering local actors in Central Africa within a network in order to work together and implement conservation actions at regional scale is an important step to effectively and sustainably protect sea turtle populations in Central Africa. In 2015-2016, Rastoma implemented series of actions according to the three priorities defined by the Rastoma

General Assembly in 2015: (1) Structuring and providing the network with collaborative and communication tools; (2) Reinforcing the capacities of members and (3) Contributing to the regional strategy to reinforce the Marine Protected Areas in Central Africa. In June 2016, Rastoma organized the first sea turtle conservation congress in Central Africa in Sao Tome (Sao-Tome-And-Principe). It gathered 30 actors from central Africa with special guests such as Rod Mast (IUCN MTSG Co Chair and Director of the SWOT), Marc Girondot (Professor at Paris University, France) and Mayeul Dalleau (from Kelonia, La Réunion, France). The Congress was also the occasion to hold the general meeting of the network and to draw the network strategy and framework-actions in a participative manner. Tasks are then distributed among the members and implemented by working groups defined during the general meeting. Workflow is ensured thanks to quarterly board meetings in Central Africa, complemented by regular meetings and through the collaborative tools available online. To comply with its capacity building objective, Rastoma organized several practical and theoretical training sessions, first in Sao Tomé in June 2016 and then in Kribi and Limbe, Cameroon in Octobre 2016. The Cameroon training session gathered the four sea turtle conservation programs currently active in Cameroun. Rastoma has a website (www.rastoma.org) including an open section with news about Rastoma actions, a private section accessible to members only with additional documentary resources (environmental education, training resources, datasheets, etc.), a technical forum, and collaborative tools. Rastoma also provides news about its actions through its Facebook Sea Turtle African Team – Rastoma: @seaturtleafricanteam.

LIGHT BARRIERS: A DUAL-PURPOSE CONSERVATION TOOL

Wilma Katz[1]

[1]*Coastal Wildlife Club Inc.*

Laws are in place to protect sea turtles from artificial light. Staff is tasked with enforcement. Public interest is high. Advances in lighting technology facilitate turtle-safe lighting retrofits. There has been much progress toward ensuring dark beaches which are safe for sea turtles, but hatchling disorientation hotspots persist. The beach at a multi-unit property on Manasota Key, Florida, is one such hotspot. For decades, disorientations here were a predictable, annual occurrence. More recently, disorientations, though less frequent, have continued, despite management engagement, compliance with local ordinances, and the use of turtle-safe light fixtures. In this location, probable contributing factors include exterior and interior lights, vehicle lights, gaps in the silhouette of the buildings, changes in beach elevation, cumulative, indirect ambient light, distant sky glow, and the proximity of most of the above to sea turtle nests. Temporary, artificial light barriers such as silt screens have been effective in reducing the occurrence and severity of hatchling disorientations, but for many reasons, they are a flawed solution. In particular, they send the wrong message. Artificial light barriers are not an acceptable alternative long-term to best available light management techniques. Artificial obstructions on nesting habitat are not OK. To correct the messaging, light barriers where still necessary in disorientation hotspots now will be information boards, sets of portable mini-billboards. The 2017 iteration of light barriers will be a dual-purpose conservation tool providing protection to sea turtle hatchlings while sending the right message to people that care about them.

HOW TO REGULATE SWIM WITH SEA TURTLE TOURISM? CASE STUDY IN PERU*

Shaleyla Rosa Gonzalez Kelez[1], Cristina Santos Perez[1], Ximena Velez-Zuazo[1], Maria Antonia Tigre[2]

[1]ecOceanica, Peru
[2]Cyrus R. Vance Center for International Justice, USA

For the past three years, turtle-watching tourism in Peru has experienced a boom. This tourism is exclusively limited to a locality on the north coast. The activity is based on the attraction of green turtles (*Chelonia mydas*) to a fishing pier by using bait, mainly giant squid (*Dosidiscus gigas*). This tourist novelty, swimming with sea turtles, is nowadays a great attraction for national visitors but also for foreigners. On a given weekend, up to 4000 people can enter the pier to see sea turtles. As a result, the fishing community has obtained great economic benefits, but also the tour companies operating in the vicinity. Moreover, communities bordering this area have begun imitating this activity by attracting turtles to their docks and are already performing these activities of observation and swimming with green turtles. A tangible benefit is that sea turtle harvest in these areas has been greatly reduced. Turtles have gone from being a fishing object to an asset worth protection due to the economic benefits it provides them.Wildlife tourism requires a regulation to be conducted in an harmonious way with the environment and the species involved. In Peru, there is still no legal framework to regulate watching of marine fauna, not even for whalewatching, an activity that has been carried out for more than 8 years. In collaboration with law firms, we conducted a study of comparative legislation on marine turtle tourism in several countries including Ecuador, Costa Rica, Mexico, Australia, Cayman Islands, and USA to determine whether (1) regulation existed, (2) what entities were involved in its implementation and control, (3) and what were the activities allowed, prohibited, and their specifications. In addition, we reviewed studies on changes in the behavior of sea turtles in the presence of swimmers.

ADVANCING AREA-BASED PLANNING AND NETWORK APPROACHES IN AREAS BEYOND NATIONAL JURISDICTIONS: A GLOBAL REVIEW OF DATA ON MIGRATION AND AREAS WITH SPATIAL CONNECTIVITY FOR SEA TURTLES*

Connie Y. Kot[1], Daniel C. Dunn[1], Corrie Curtice[1], Eleanor Heywood[1], Guillermo Ortuño Crespo[1], Jesse Cleary[1], Ei Fujioka[1], Benjamin Donnelly[1], Patrick N. Halpin[1]

[1]Marine Geospatial Ecology Lab, Duke University

The Convention on Biological Diversity (CBD) has developed scientific criteria and guidance for identifying ecologically or biologically significant marine areas (EBSAs) to represent open ocean areas that serve important purposes, including areas that are required for highly migratory populations to survive and thrive. In an effort to assist the CBD to move the EBSA process forward from isolated sites to a network approach and advance area-based planning for the conservation of highly migratory species in areas beyond national jurisdictions, an in-depth literature review of data gathered by various methods (e.g., telemetry, mark-recapture, stable isotopes, genetic samples, etc.) is currently being conducted to examine global migratory routes and connected sites used by sea turtles, marine mammals, seabirds, and fishes. Standardized protocols for reviewing and collating sea turtle data are initially being tested on loggerhead *Caretta caretta* and leatherback *Dermochelys coriacea*. Information on sites (areas used for a particular activity such as feeding or nesting) and routes (paths animals use between sites) will be summarized and digitized to evaluate migration and connectivity. Data extracted from the literature or from direct

contributions of collaborating partners will be further aggregated to higher-level features, including nodes (aggregations of sites), corridors (aggregations of routes), and connections (aggregation of connected features). These data will be accessible within an online geospatial database and application to better enable analyses of the current state of and identify knowledge gaps on migratory corridors and connections. Furthermore, the literature review can facilitate the identification of mesoscale pelagic habitats and future habitat modeling needs in support of global biodiversity indices and large-scale marine spatial planning, particularly in the high seas.

COLLABORATION BETWEEN DUKEENGAGE AND DEKAMER SERVES AS A MODEL FOR OTHER ENVIRONMENTAL CONSERVATION PROJECTS

Alexander Lee[1], Michael Rosamilia[1]

[1]*Duke University*

DukeEngage, offered by Duke University, seeks to empower undergraduate students to approach critical global needs through fully funded, 2-month immersive service programs. Specifically, the DukeEngage in Turkey program sends nine undergraduate students each summer to focus on the service theme of environmental conservation through work at the DEKAMER Turtle Project on Iztuzu Beach in Dalyan, Turkey. The DEKAMER turtle project is responsible for monitoring nesting loggerhead females, a protected species in Turkey and elsewhere, protecting incubating eggs from May through early August, and rehabilitating sick or injured sea turtles. Volunteers here are directly involved in all aspects of this work, including nighttime patrols on the nesting beach, care and husbandry of turtles in the rehabilitation center, and environmental education by leading tours at the center. The relationship is mutually beneficial for DEKAMER and the DukeEngage participants, as it provides opportunities and experiences in hands-on conservation and education efforts for the Duke students while also providing a reliable workforce for DEKAMER. The Duke students working at DEKAMER serve as a bridge between learning and research, as the experience catalyzes learning while also actively collecting data that is crucial for monitoring and conservation of loggerhead sea turtles. Thus, the effectiveness of this program can serve as a model for other environmental conservation projects that wish to engage curious undergraduate students.

APPLYING THE CONSERVATION PRIORITIES PORTFOLIO AT THE POPULATION LEVEL TO EVALUATE THE OLIVE RIDLEY TURTLE: THE PERCEPTION OF LOCAL EXPERTS FROM THE NORTHEAST COAST OF BRAZIL

Gustave Gilles Lopez[1]

[1]*Universidade Federal da Bahia - UFBA*

Sea turtle populations are ecologically important in marine ecosystems and have cultural, educational and conservationist appeal. Hence the relevance of evaluating and measuring the factors that affect the resilience of these populations. The Olive Ridley (*Lepidochelys olivacea*) has circumglobal distribution, being considered in a Vulnerable situation by the International Union for Conservation of Nature (IUCN). In Brazil, it is evaluated as Endangered. The country's nesting population has its main reproductive area the coast between the extreme north of Bahia, Sergipe and south of Alagoas. The objective of this work is to investigate the factors that threaten this population through the perception of local experts directly involved in the conservation efforts. Semi-structured interviews were conducted on factors that threaten this

population with 7 experts. All of them work with the species at Projeto Tamar, an organization that performs research, conservation and management of sea turtles. The factors evaluated include a first group directly related to climatic changes: population size, recent spawning tendency, long-term spawning tendency, spawning area vulnerability and genetic variability. The second concerns risks not related to climate change: incidental catch in fishing, direct use, coastal development in the areas of spawning and pollution / pathogens. These factors were quantified on a scale of 0 to 3, according to the value assigned by each specialist. The main threats identified were: capture during shrimp trawl fishing, coastal development, low genetic diversity and predation of eggs by foxes. Shrimp fishing causes the annual death of 200 adult turtles per year at the reproductive area. Mitigating measures have been taken (e.g. establishment of 2 annual closed seasons, minimum fishing distance and educational campaigns). Real estate constructions and associated artificial illumination deprive the reproductive area, causing nests loss or diminution, disorientation of females and hatchlings, being among the main threats to the population.

EVALUATION OF TRUST TIES AND NEGOTIATION STRATEGIES DEVELOPED FOR SEA TURTLE CONSERVATION AT PIRAMBU, SERGIPE, BRAZIL*

Gustave Gilles Lopez[1], Ana Ruth Rodrigues de Jesus[1], Camila Felix de Lima Fernandes[1], Rilquer Mascarenhas[1], Fábio Costa Nunes[1], Luiz Humberto Castro de Freitas Filho[1], Alexandre Igari[2], Charbel El-Hani[1]

[1]*Universidade Federal da Bahia - UFBA*
[2]*Universidade de São Paulo*

“Ecological resilience” is the ability of a system to absorb changes and disturbances while maintaining its behavioral regime. This concept applies both to purely ecological and socio-ecological systems. One of the constraints to the resilience of socio-ecological institutions is the establishment of bonds of trust among the actors and organizations involved, increasing the chances of conflict negotiation and building win-win strategies. In order to obtain a useful and practical approach to trust in Natural Resource Management Institutions (NRMI) a group of researchers outlined four main types of trust: "Dispositional" (based on predisposition of one actor to trust the other or not); "Rational" (referring to what the actors believe to be the probable result of the possible actions of other actors or institutions); "Affinitive" (based on the affinity between the actors involved) and "System-based" (trust in a set of procedures or rules). The greater the diversity of bonds of trust, the greater the NRMIs resilience. An example of NRMI in Brazil is Projeto Tamar, which began activities in the early 1980s and until today has a fundamental role in protecting sea turtles along the Brazilian coast. One of the first Tamar stations is located at Pirambu, a 10,000 inhabitants city located in the state of Sergipe. The primary economic activity in the region is fishing, with an emphasis on shrimp trawling, which directly impacts sea turtle conservation. Additionally, the region has relevance in the study and conservation of sea turtles, because it is considered the main nesting ground for olive ridleys *Lepidochelys olivacea*, with more than 8,000 nests per reproductive season. In the past, this area was also characterized by a large consumption of sea turtle eggs and meat, which provoked the decline of sea turtle populations. Nowadays, as a result of conservation work, these activities are not considered a threat to these animals anymore. The present work aimed to evaluate the establishment of trust ties between Projeto Tamar and the local community of Pirambu.

AN UPDATE ON THE RESEARCH AND MANAGEMENT NEEDS FOR THE SEA TURTLE POPULATIONS OF MYANMAR*

Maung Maung Lwin[1], Martin Callow[2], Robert Howard[3], Douglas Hykle[4], Colin Limpus[5], Tania Miorin[6], David Owens[7,8]

[1]*Myanmar Department of Fisheries*
[2]*Wildlife Conservation Society*
[3]*Fauna and Flora International*
[4]*IOSEA Marine Turtle MoU Secretariat*
[5]*Queensland Department of Environment and Heritage Protection*
[6]*Instituto OIKOS Myanmar*
[7]*Mawlamyine University*
[8]*University of Charleston*

With more than 1000 islands, 2900 kilometers of coastline and extensive coral reef, sea grass pasture and mangrove forest, the Union of Myanmar has major nesting and foraging ground habitat for its five species of sea turtles. Genetically distinct Olive Ridley and Green Turtle populations would appear to be especially important in the region. Despite very early attempts at egg harvest regulation (see Maxwell, 1911 in D. Hykle, unpublished) and only limited meat consumption, Myanmar sea turtle nesting and foraging ground populations are in extreme decline (see abstract # 120 by Ko Myint et al.). In 2016 sets of Ranked Conservation and Research Priorities were developed: Protect Adults and juvenile turtles in Myanmar Waters, Develop improved methods for incubation and protection in sea turtle hatcheries. Initiate community and regional "brainstorming" discussions to improve local involvement in conservation initiatives. Develop a national plan/strategy for sea turtle protection. Update information/data about in situ nesting of all sea turtle species. Monitor and tabulate nesting success surveys. Study nesting beach temperature profiles relative to TSD and climate change. Use Flipper and satellite tags to track turtles to understand ranges and distribution. Improve Intergovernmental communication systems. Engage local communities through education and conservation programs. 8. Develop a national database on nesting, habitat and tracking information.

A THEORY-BASED EVALUATION OF THREE DECADES OF LIGHTING ORDINANCES FOR SEA TURTLE PROTECTION IN FLORIDA*

Jame McCray[1]

[1]*University of Florida*

Creating efficacious laws are especially important for the conservation of endangered species where the point of no return may be reached before conclusive empirical data can be examined about how well a policy is working. Implementation researchers have used tools like theory-based evaluation (TBE) to analyze the structure and outcomes of policies in sectors like welfare, health policies, and more recently climate change legislation. A theory-based evaluation is a type of direct logic analysis that allows us to see whether an intervention is designed in such a way as to achieve the intended outcomes. Typical of most policy instruments, the policy-theory governing lighting ordinances is implicit, that is how the policy makers believe the items contained in the policy will lead to the desired outcomes is not explicitly described. The logic chain of lighting ordinances was identified by analyzing the Department of

Environmental Protection model lighting ordinance in conjunction with the laws that were adopted, in addition to interviews with compliance agents. Using the TBE approach we were able to integrate the literature on regulatory compliance, implementation and social science behavioral theories to identify (1) logical flaws in the policy theory, (2) gaps in policy framework that would lead to the policy to be ineffective, and (3) solutions that can improve the chances of the policy to be effective.

NORTH COAST OF THE CUBAN SHELF: A MIGRATORY CORRIDOR FOR SEA TURTLES IN THE CARIBBEAN SEA REGION

Félix Moncada-Gavilán[1]

[1]*Centro de Investigaciones Pesqueras, Cuba*

The Cuban shelf constitutes an important area for foraging, nesting and at the same time a migratory corridor within the Caribbean Sea region for the Green turtle, Loggerhead and the Hawksbill turtle. Results obtained mainly from the metallic tagging indicated these species move to the east and west directions (favor and against the current), a movement towards the east prevailing for the Green turtle and the Hawksbill turtle, and a movement towards the west for the Loggerhead turtle. For this reason, it was proposed for the north coast of Cuba the possibility of constituting a migratory route for turtles of the three species on routes to habitat destinations on the southern coast of Cuba or to other sites (Moncada et al., 2006, 2010 And 2012). However, new evidences from satellite tracking of turtles from other areas of the Caribbean confirm that these turtles when they arrive to Cuba in transit along the north coast. Taking into account that the knowledge of migratory corridors is of vital importance for the development of effective international strategies for the conservation of sea turtles (Morreale et al., 1996), and also that for the study of their existence, studies are generally based mainly on the movements of post-nesting females observed within the same season; this paper aims to provide new elements based on tag-recapture data previously studied, but this time analyzed with this objective, and considering the data within each year, and / or tagging station, the size groups for each species and their movement along the coast. Information is also provided on turtles trawled in other areas swimming along the northern coast of Cuba, demonstrating and confirming the north coast of the Cuban shelf constitutes a migratory corridor that includes different species of turtles in different stages of life.

TURTLE ACTION GROUP OF SEYCHELLES (TAGS)*

Jeanne A. Mortimer[1]

[1]*Turtle Action Group of Seychelles*

The Republic of Seychelles in the Western Indian Ocean comprises more than 115 islands spread over an area of some 400,000 km^2, virtually all of which host nesting populations of hawksbill and green turtles. Some 20 intensive turtle monitoring programs operate in Seychelles, including 12 in the inner islands, 7 in the outer islands, and additional projects in the planning stage. Projects are operated by a variety of stakeholders including NGOs, private island owners, hotels, parastatal organizations, and Government Ministries. Some projects have been underway since the 1970s. Basically the same monitoring protocols have been employed at all sites, but the need for the turtle monitoring projects to coordinate their efforts in order to share data has long been recognized. Efforts to bring the turtle programs together under a single umbrella eventually led to formation in 2008 of an independent, registered association, the Turtle Action

Group of Seychelles (TAGS). TAGS has a Constitution of Association and an "MoU on Cooperation to Promote Turtle Conservation in Seychelles and on the Sharing of Information". Funding has been obtained from the Save Our Seas Foundation (SOSF) and Government of Seychelles to strengthen the group and to assist TAGS in production of a website that will serve as a forum to educate people within and outside Seychelles about the status and trends and the biology and natural history of the Seychelles sea turtle populations, as well as an overview of past and present efforts to understand and conserve sea turtles in Seychelles.

IMPORTANCE OF A PROPER DATA COLLECTION ON MARINE TURTLE STRANDINGS*

Patricia Ostiategui-Francia[1], Alejandro Usategui-Martín[1,2], Andrea Fariñas-Bermejo[3], Ana Liria-Loza[3]

[1]*University of Las Palmas de Gran Canaria*
[2]*Instituto EcoAqua*
[3]*ADS Biodiversidad*

Every year hundreds of marine turtles are stranded in the Canary Islands, and most of them arrive at the different Wild Fauna Recovery Centers (WFRC) scattered across the islands. The most abundant species in the Canarian waters is loggerhead turtle (*Caretta caretta*), which is described as a foraging ground for juveniles of different colonies (Florida, USA; México and Cape Verde). The large migratory movements of loggerhead turtles, as well as the geographical position of the Canary Island –located in the middle of Canary Current-, conclude that turtle stranding causes in the Canary Islands provide important information about marine turtles threats in the East Atlantic Ocean. Therefore, it is important that these data are as accurate as possible. This study aims to analyze marine turtle stranding databases, collected over 12 years (2003 – 2015) by the Fuerteventura Recovery Center to identify different perceptions and mistakes on data collection along the time and to determine how significant the error could be for further studies. For this, main stranding causes were classified in 10 categories. After that, the database was analyzed in two different ways: 1. Including "misleading data" as a new category for those turtles which stranding cause were not properly recorded. All data which don't have the stranded cause recorded exactly as one of the previous categories was classified as misleading data; 2. Stranding causes of turtles whose data were not properly recorded was deduced from the observations on the data sheet (when it was possible). Results of this study would show how a poor data collection would affect the results of the future study and the importance of a proper data collection not only focuses on studies but also on the implementation of conservation strategies and threatened species directives. It also wants to emphasize the importance of adequate data collection protocols established in different WFRC.

THE ONLY VET IN THE MALDIVES! SETTING UP A MARINE TURTLE RESCUE CENTRE IN AN ISLAND NATION

Claire Petros[1], Jillian Hudgins[1], Martin Stelfox

[1]*The Olive Ridley Project*

The Olive Ridley Project (ORP) has teamed up with Coco Collection, a chain of resorts in the Maldives, to create a Marine Turtle Rescue Centre. The project has a full-time veterinarian, making the rescue centre the first of its kind as, to our knowledge, never before has a full-time veterinarian been hired in the

Maldives. The aim of the centre is to provide medical support to injured sea turtles, specifically those that have been entangled in ghost nets. Ghost nets are fishing nets that have been abandoned, lost, or discarded. The detrimental effects of ghost nets can be felt far from their point of origin and can exist for decades, traveling vast distances. These nets can continue to entangle marine animals long after they have entered the ocean, a process called "ghost fishing". Entanglement can lead to exhaustion, suffocation, starvation, amputations, and, eventually, death. In the last three years over 300 turtles have been rescued from ghost gear in the Maldives. The majority of turtles found entangled are *Lepidochelys olivacea*. Local fishers, marine biologists, and recreational divers have all rescued entangled turtles. Previously these turtles were either immediately released once disentangled, or sent to centres run by marine biologists to receive variable forms of first aid. It is the intention of the ORP that these severely injured turtles receive appropriate medical care until they are deemed fit to be released. The centre will also be an outreach program for local schools, hosting field trips and presentations. It will also serve as a training centre for young Maldivians in a country where no other opportunities for training in veterinary medicine are available. An important goal of this rescue centre is to centralise the treatment of these turtles by advertising its existence via means such as social media. Social media (e.g. Facebook) allows news of an entangled turtle to be received and acted upon in real-time. The project is currently in the process of acquiring the help of the national sea plane company to transport injured turtles. There are over 180 resorts in the Maldives spanning an area of 90,000 square kilometres. We will require a collaborative effort locally to get these turtles to us so that we can provide the care that they need. This can only be achieved by greater awareness of the centre, by means of advertisement, word of mouth and, social media. This use of social media is crucial in the development of our centre, but also in the continual education of not only those local to the islands but of tourists visiting too.

ASSESSING OCEANIC JUVENILE SEA TURTLE MOVEMENTS IN THE CONTEXT OF MARINE PROTECTED AREAS IN THE GULF OF MEXICO*

Katrina Phillips[1], Katherine L. Mansfield[1]

[1]*University of Central Florida*

Habitat protection is a useful tool for supporting population recovery in imperiled species. Characterizing habitat use is difficult for marine organisms, particularly highly migratory species such as sea turtles. Field observations and telemetry studies provide valuable insight into habitat use, providing the data needed to identify target locations for protected habitat. Several areas are currently designated as 'critical habitat' for loggerhead turtles (*Caretta caretta*) under the U.S. Endangered Species Act, including some adult migratory routes, nesting beaches, and breeding areas, as well as oceanic juvenile Sargassum habitat. Many of the areas identified are found within the Gulf of Mexico, a diverse environment that supports numerous sea turtle species and life stages. No critical habitat is currently designated in the Gulf of Mexico for adult or immature Kemp's ridley (*Lepidochelys kempii*), green turtles (*Chelonia mydas*), or hawksbills (*Eretmochelys imbricata*). We tracked 71 wild-caught oceanic juveniles in the Gulf of Mexico using small solar-powered satellite tags between 2011 and 2016, including Kemp's ridleys, green turtles, hawksbills, and loggerheads. We evaluated the overlap of capture locations and subsequent movements with established state and federal marine protected areas, including the Sargassum critical habitat designated for loggerheads. We also evaluated the proximity of oil platforms and associated pipelines. The majority of individuals tracked entered a marine protected area during the tracking period. However, gaps exist, particularly for Kemp's ridleys and green turtles in the eastern Gulf of Mexico. Three tracked turtles exited the Gulf of Mexico, and the majority of their locations while within U.S. waters fell within Sargassum critical habitat. Several turtles were tracked beyond U.S. jurisdiction, illustrating a need for international coordination to manage important habitats and support population recovery for these species.

REDUCING SEA TURTLE INCIDENTAL TAKES BY HOPPER DREDGES: PARTNERING WITH STAKEHOLDERS IN THE DEVELOPMENT OF A DECISION SUPPORT TOOL*

Doug Piatkowski[1], J. Jacob Levenson[1], Connie Y. Kot[2]

[1]U.S. Department of the Interior
[2]Duke University, Marine Geospatial Ecology Lab

The Bureau of Ocean Energy Management's (BOEM) Marine Mineral Program (MMP) authorizes the use of Outer Continental Shelf (OCS) sand resources for shore protection and coastal restoration projects. The potential for entrainment and mortality of federally protected sea turtles is one of the significant factors that impacts how and when projects can be conducted using Trailing Suction Hopper Dredges (TSHD) to extract these resources. As a responsible steward of OCS resources, the BOEM seeks to minimize adverse environmental effects related to project specific dredging operations through deliberate planning efforts and the implementation of relevant and effective mitigation measures. Historically, the US Army Corps of Engineers, Industry, Academia, and other partners have made significant investments in improving protective measures and best management practices, principally focusing on dredging windows, the use of sea turtle deflecting dragheads, dredging operational parameters, and relocation trawling. However, less emphasis has been placed on analyzing existing data and subsequently tailoring these mitigation strategies on a project and/or geographic-specific level. Based on an analysis of historic incidental sea turtle takes in offshore borrow areas, several factors have been linked to increased take risk beyond assumptions of presence/absence relative to water temperature including: (1) temporal and spatial relationship of sea turtle behavior within the water column (e.g., foraging, migrating, etc.) relative to draghead operating parameters and (2) borrow area design relative to turtle deflecting draghead efficacy. Considering the full array of all risk factors within the project specific context, targeted mitigation strategies may be more effective than conservative presence/absence-based dredging windows. The purpose of this study is to bring together a select group of technical experts with a broad knowledge base and understanding of the relationship of dredging entrainment risk relative to sea turtle distribution and behavior, dredge operational parameters, and the implementation of existing mitigation measures. Technical insight will be used to inform the development of standardized geographically and temporally based decision support tool for use by practitioners in the Atlantic and Gulf region to assess project-specific dredging entrainment risk within a common framework. The tool will be used to guide mitigation planning decisions within marine mineral resource areas. More informed decisions may minimize impacts to sea turtle species while also decreasing dredging costs through reduced downtime associated with entrainment incidents and potentially allow more flexibility of environmental windows in areas with less risk.

NATIONAL ACTION PLAN FOR THE CONSERVATION OF SEA TURTLES IN ARGENTINA

Laura Prosdocimi[1], Gabriela S. Navarro[1]

[1]Ministerio de Agroindustria

The Argentinian Sea is the southernmost distribution and feeding ground for four sea turtle species: the green turtle (*Chelonia mydas*), the loggerhead turtle (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*) and the leatherback turtle (*Dermochelys coriacea*). In 2003, several local organizations and institutions drew up a diagnosis report in order to gather the information of all the reports and records of sea turtles in the country. From this report, it was founded that the presence of sea turtles was common in the Argentine

coast and riverine sector. As a result, the basis for the creation of the Regional Program for Research and Conservation of Argentinian Sea Turtles (PRICTMA) were founded, in order to optimize and enhance research efforts of each institution. Moreover, it aims to define which is the role of the Argentinian Sea in the life history of sea turtle populations in the Atlantic Ocean and identify different conservation problems faced in our waters. The program´s main research lines are: use of habitat and migrations, origins of see turtles, dietary studies and monitoring of health status, among others. The main threats affecting sea turtles in the Argentinian Sea are habitat alteration, bycatch in fishing nets and marine debris pollution, which are mainly plastics from anthropic solid waste from urban areas. With this background, in 2010, the National Law nº 26,600 sanctioned the participation of Argentina in the Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC) and in 2011 its instrument of ratification was deposited. Since then, with the National Ministry of Environment and Sustainable Development (MAyDS) as the enforcement authority of the CIT, it has been developed a joint working state on the issue with various state agencies, civil society organizations and institutions dedicated to research. In 2014 began the work process for the development of a National Action Plan for the Conservation of Sea Turtles in Argentina (PAN - TM); in November of the same year, a workshop involving national government and provincial agencies, members of the scientific sector and nongovernmental organizations was held. As a result of that meeting the PAN - TM was drafted, which was comprised of two programs that address actions on the major threats affecting marine turtles in our country: (1) National Action Program to Reduce the Interaction of Marine Turtles with Fisheries in Argentina. (2) National Action Program to Reduce Sea Turtle interaction with marine debris in Argentina. In November 2015 as a result of the resolution No. 317/2015, The COFEMA approved the program referred to interaction with marine debris and latter in November 2016 the Fisheries Federal Council approved the program referred to interaction with fisheries. Thus, the national action plan for the conservation of sea turtles in Argentina was formed. This plan presents a technical advisory group working within it.

THE EO4WILDLIFE PLATFORM - A NEW TOOLBOX TO MAXIMISE ACCESS AND PROCESS EARTH OBSERVATION DATA

ALan F. Rees[1]

[1]*University of Exeter, UK*

The main objective of the EO4wildlife (EO4W) platform is to bring large communities of multidisciplinary research scientists to collaborate closely together while using European Sentinel Copernicus Earth Observation data more extensively and efficiently. EO4W research specialises in big-data intelligent management, processing, fusion and advanced analytics with a Knowledge Base for wildlife migratory behaviour trends. The outcome will be development of web-enabled, open services using OGC standards for sensor observation and measurements and data processing of heterogeneous geospatial observation data and uncertainties. In order to reach such an important objective, an open service platform with an interoperable toolbox will be designed and implemented. The platform will offer high level big data services that can be accessed by scientists to perform their respective research on species behaviour linked to environmental conditions and change of those conditions under certain threats. Also, the platform front end will be intuitive to use and access by scientists. It will reduce barriers to accessing dedicated big data services for processing geospatial environmental simulations using Sentinel Earth Observation data which are intelligently fused with in-situ observation data from other sources. The project incorporates a dedicated Sea Turtle Reference Scenario and Work Flow. This will comprise a number of tools to permit the user manipulate their tracking data and generate meaningful products, such as home range estimates and behavioural state assignments, tied-in with a comprehensive suite of remote-sensed Earth Observation data. Additionally, the system will facilitate exploratory habitat modelling, combining tracking data with

environmental variables. Sea turtle researchers will be able to gain initial insights into behaviour and distribution of tracked animals, before conducting more in-depth analyses.

THE TAOLA NETWORK: A TOOL FOR NATIONAL SEA TURTLE CONSERVATION AND COORDINATION IN CAPE VERDE

Leno Dos Passos[1,2]

[1]TAOLA Sea Turtle Network
[2]Maio Biodiversity Foundation

The Cape Verde Archipelago hosts the largest nesting ground for loggerhead sea turtles in the Eastern Atlantic. Sea turtle conservation work in Cape Verde began in 1987 when the first law was approved by National Government which prohibited turtle hunting from July to February. In the 1990s the University of Gran Canaria (Spain) started sea turtle projects on Boavista Island. In 2002 the first law protecting sea turtles year-round was passed. Nevertheless, the laws have not been effective at tackling meat consumption and egg poaching. Currently a draft of a comprehensive law on sea turtles is under revision, and contemplates the criminalization of turtle hunting, trade and consumption. Since the late 1990s, every year more governmental agencies, local municipalities, NGOs and other organizations started to protect nesting females and monitor nesting beaches in every corner of the archipelago. Although the local results were positive, there was a lack of coordination among them to influence the national agenda, integrate protocols and databases and exchange experiences. In 2009 U S Fish and Wildlife Service provided support to unify and coordinate efforts at the national level and a national meeting was organized. It was agreed that this should be a regular annual meeting and TAOLA (TArtaruga CriOLA - translated:Creole Turtle) the Cape Verdean Sea Turtle Protection Network was born. The main objectives of TAOLA are to promote coordination among sea turtle conservation efforts and increase the synergy between the conservation groups, while providing to future generations a healthy and ecologically balanced environment and promoting the implementation of the National Action Plan for the Conservation of Sea Turtles in Cape Verde. Since the creation of TAOLA, all the institutions that work with the conservation of sea turtles, authorities, funders and government institutions have had an opportunity to share the results of their work, discuss the main problems affecting the conservation of sea turtles in Cape Verde and find solutions at a national level. TAOLA members communicate regularly and meet annually before the nesting season. The 8th meeting of TAOLA was held in Santiago in November 2016 and focused mainly on four issues: the need for a new legislation that addresses all issues regarding sea turtle conservation, increase in law enforcement and safety conditions on the nesting beaches, strategies to increase the involvement of the central government in sea turtle conservation in Cape Verde and find strategies to approach communities to reduce turtle trade and consumption.

SEA TURTLE NEST PATROLS ON THE UPPER TEXAS COAST

Joanie Steinhaus[1], Theresa Morris[1]

[1]Turtle Island Restoration Network

Of the five species of sea turtles found in the Gulf of Mexico, the Texas coast is a hotspot for the critically endangered Kemp's Ridley. Many organizations work tirelessly in hopes to preserve this vanishing creature. Since 2007, the Upper Texas Coast Sea Turtle Nest Patrol Program has primarily been organized

by Texas A&M University at Galveston (TAMUG), Help Endangered Animals- Ridley Turtles (HEART) and Turtle Island Restoration Network (TIRN). Beginning in 2014, TIRN expanded the program to include over 200 volunteers. This program had no dedicated funding, however TIRN succeeded in cover over 11,000 miles throughout each season with the help of devoted volunteers. In 2016, National Resource Damage Assessment grants were awarded and provided TAMUG the opportunity to purchase new UTVS to assist the volunteers in covering certain sections of upper Texas coast beaches. From April 1st through July 15th, volunteers either walk or drive 72 miles of beaches from Bolivar Peninsula, through Galveston and Follet's Islands ending in Freeport in search of sea turtles, crawl patterns, and disturbances in the dunes indicating nests. With the addition of the UTV's in 2016 over 15,000 miles were patrolled. The frequent coverage of the beaches has assisted in the rescue and recovery of ailed sea turtles, as well as many other species including injured birds, alligators, marine mammals and one shark. Beaches are patrolled 6 days per week, 2 shifts per day and during each shift, the volunteers TIRN recruits are given the opportunity for community outreach. This outreach includes recovery and recycling of monofilament, maintaining monofilament recycling tubes, and beach cleanup. During the five hours on patrols, these recruits are engaged with beach goers, distributing educational materials such as the 866-TURTLE 5 hotline number and information on Kemp's ridley sea turtles. Volunteers also act as observers for local beach cleaning, maintenance and restoration projects that could potentially impact nesting turtles and dunes.

BUILDING CONSENSUS FOR THE RECOVERY OF THE HAWKSBILL TURTLE, *ERETMOCHELYS IMBRICATA*, IN THE GULF OF FONSECA REGION, CENTRAL AMERICA*

Jose Urteaga[1,2], Alexander Gaos[3], Michael J. Liles[2,4,5,6], Velkiss Gadea[7], Leana Corea[3,8,9], David Melero[3,10,11], Ingrid L. Yañez[3,10], Gena Abarca[3,11,12], Eduardo Altamirano[3,10,11], Ana Henríquez[3,9]

[1]*Stanford University*
[2]*E-IPER*
[3]*Eastern Pacific Hawksbill Initiative*
[4]*San Diego State University*
[5]*University of California Davis*
[6]*Ocean Associates Inc*
[7]*Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration*
[8]*Texas A&M University*
[9]*ProCosta - El Salvador*
[10]*Fauna & Flora International - Nicaragua*
[11]*Red Nacional para la Conservación de Tortugas Marinas de Nicaragua*
[12]*UNAN - Managua*

We present results of a coastal marine participatory planning process focused on the hawksbill turtle (*Eretmochelys imbricata*) in the Gulf of Fonseca, an at-sea inlet under joint jurisdiction of El Salvador, Honduras and Nicaragua in Central America. The eastern Pacific hawksbill is considered one of the top nine most threatened sea turtle management units in the world and approximately 90% of the known nesting population occurs in the Gulf of Fonseca and surrounding areas. In June 2014 we facilitated a workshop in each country (three workshops total) as input for the development of the recovery plan for hawksbills in the region. We used conflict resolution and strategic planning techniques to identify the most salient perceived problems and required/suggested strategies. In total, we collected data from 107 participants, which included community leaders, government officers, private sector managers, and environmental NGO staff. Through workshop exercises we listed and ranked 44 direct or indirect impacts on hawksbills and their habitat. These threats were grouped in three major categories; nesting beaches, fisheries interactions,

and coastal development. Additionally, although climate change issues were not explicitly included in the guiding questions, participants demonstrated a strong concern regarding related phenomena, such as droughts, floods and sea level rise. These issues were captured transversally within the three major threats categories and subsequent required actions. In this presentation we summarize the results of the consultation process and highlight implications for management of hawksbills in the region. We conclude that conservation problems associated with hawksbills are entangled with broader coastal zone use conflicts. Therefore, sea turtle conservation sustainability is contingent on comprehensive improvements in the environmental governance of the Gulf of Fonseca Region.

APPLICATION OF A UAV TO MONITOR MARINE TURTLE NESTING ACTIVITY FOR A MAJOR INDUSTRY RESOURCE DEVELOPMENT IN WESTERN AUSTRALIA*

Paul Whittock[1], Robert Ryan[1], Kellie Pendoley[1]

[1]*Pendoley Environmental*

Technological advancements have seen a rise in the application of Unmanned Aerial Vehicles (UAVs) to address a wide variety of subjects relating to the biology and conservation of wildlife. More recently, UAVs have been tested as a tool to monitor marine turtle activity situated both on- and offshore. One main driver for the rise in use of UAVs is that in some cases, it removes the need for on-the-ground or offshore monitoring by personnel in the field and hence eliminates the health and safety risks of working in potentially remote, dangerous or inaccessible areas. Recognising the advances and potential advantages of UAVs, we were commissioned by a client to demonstrate the viability of using a UAV to meet a monitoring commitment required as part of the environmental approvals process for a major resource development in Western Australia. The commitment outlines the need to monitor marine turtle nesting activity (i.e. track counts) on a beach in close proximity to the development and, historically, has been undertaken by on-the-ground field personnel. To complete the survey, we used a commercially available UAV (DJI Phantom 4) to record aerial imagery of the beach at a resolution suitable for determining track activity and species. The UAV was flown on a set flight path and altitude over multiple days. All imagery data was georeferenced and orthomosaicked for visualisation in GIS software. On-the-ground monitoring was conducted concurrently to determine the accuracy of track counts detected from imagery data and to prove the viability of UAVs as a monitoring tool for this purpose. Here we present the survey design and planning considerations prior to undertaking a commercial UAV operation in Australia, the health and safety considerations in undertaking a UAV survey and the actual application and performance of the UAV in the field. We also present the comparison results between the nesting activity detected by the UAV and the on-the-ground monitoring field team and discuss the viability and limitations of the UAV as a monitoring tool.

Education, Outreach and Advocacy

FROM HUNTERS TO CONSERVATIONIST: SEEKING TO CHANGE THE WAYS IN WHICH RURAL COMMUNITIES IN NIGERIA SELF-IDENTIFY*

Felix Abayomi[1]

[1]*Wildlife Africa Initiative*

It begins in the Spring of 2016 with one Nigerian man, an employee of his country's Wildlife Management Division, who is studying in Spain. That man is me. At that time I am nearing completion of a Master's Program at the Universidad Internacional De Andalusia and the subject is Wildlife Management and Conservation of Species. Although I am greatly inspired by all that I am learning, I am also at a loss. How shall my new knowledge be used when I get home? In a country that effectively has no program of environmental education running in its schools and no wildlife rescue and rehabilitation centres, how could one man possibly hope to make a difference? And where to begin? Serendipitously, as my period of study was drawing to an end, I happened upon some footage of a sea turtle captured on the shores of Nigeria and taken for sale in the markets of Lagos. I knew immediately I wanted to do something about this trade, and from that time my efforts have been focused primarily on sea turtles. I shall be presenting the current conservation climate in Nigeria as well as the events that led, within a few short months, to the founding of a new conservation NGO, "Wildlife Africa" and, under its auspices, a sea turtle education and awareness program, "Project Ariyikes*" with its travelling sea turtle exhibition designed for schools. I shall be presenting the work to date of both initiatives and, highlighting how the case of a single animal and its rescue can become the catalyst for community engagement locally and transform the way in which people are able to identify themselves – making the gradual transition from 'hunters' to 'conservationists'. I shall also be demonstrating the importance of the international support that has been received by Project Ariyikes, showing the contributions made by sea turtle scientists (in Italy and the US), providers of educational materials (from Germany) and experienced communicators (based in the UK). Ours is the first effort to protect and conserve the sea turtles that visit Nigerian waters and nest on Nigerian beaches. *Arikiye translates from the Yoruba language of South-West Nigeria as "See me and care for me".

COMMUNICATIONS CAMPAIGN FOR MARINE TURTLE CONSERVATION IN CUBA

Julia Azanza-Ricardo[1], Yanet Forneiro Martín-Viaña[2], Jose Gerhartz-Muro[3], Félix Moncada-Gavilán[4], Yosvani Medina-Cruz[4]

[1]*Instituto Superior de Tecnologia y Ciencias Aplicadas*
[2]*Empresa Nacional para la Protección de la Flora y la Fauna*
[3]*La Fundación Antonio Núñez Jiménez de la Naturaleza y el Hombre*
[4]*Centro de Investigaciones Pesqueras*

As a part of the Cuban efforts to promote marine turtle conservation in Cuba several educational activities have been developed in two main directions: capacity building and public awareness. Regarding public awareness a children's book illustrated with colour pictures was designed explaining the life cycle of marine turtles and the main threats they are facing worldwide and in Cuba in particular as well as conservation actions that we can make. A handbook for environmental educators was also prepared to implement education and communication campaigns in communities. All this preparation allowed the

successful organization of marine turtle festivals in more than 10 coastal communities around Cuba. However, the most severe threat to marine turtles in Cuba is poaching. A network of private restaurants in coastal cities with high number of foreign visitors such as Havana, Varadero, Cienfuegos, Trinidad, Santiago de Cuba and Baracoa are areas of high demand of this type of meat. Illegal commerce and trafficking of hawksbill shells and handcrafts also occurs in different parts of the country creating additional demand. Those were the reason to start a social communication campaign directed to hawksbill products consumers to prevent illegal trade and international commerce. This national campaign includes the use of pictures exhibitions with the consequences for turtles of this trade and the importance and beauty of marine turtles, printed T-shirts, exchange with press among other actions. Although the expected impacts of this campaign are not achieved yet general public agrees that they see differently they role as consumers of this products and what they can do to reduce illegal trade.

ENGAGING SAN DIEGO'S UNDERSERVED YOUTH IN SEA TURTLE RESEARCH EXPERIENCES IN BAJA CALIFORNIA, MEXICO*

Joel Barkan[1], Shara Fisler[1], Wendy E. D. Piniak[2], Yonat Swimmer[3], John H. Wang[3]

[1]Ocean Discovery Institute
[2]Gettysburg College
[3]NOAA NMFS Pacific Islands Fisheries Science Center

Ocean Discovery Institute is a San Diego, California-based non-profit organization that uses ocean science to empower young people from underserved urban communities to transform their lives, their community, and our world as scientific and conservation leaders. Ocean Leaders is an Ocean Discovery Institute initiative that engages underrepresented students in a series of interconnected after-school and summer programs, offering a pathway for these students to progress from secondary school through college and on to careers in science and conservation. A cornerstone of Ocean Leaders is the "BAHIA" program: an intensive research experience in Baja California, Mexico, through which students conduct authentic research alongside scientists from government agencies and academia. This experience includes a rigorous preparation period; field work in Bahía de Los Angeles; data analysis; and presentations at scientific meetings and to the San Diego community. Since 2006, nearly 100 high school and college students have participated in sea turtle research projects in Bahía de los Angeles and Punta Abreojos. The project's unique model brings together sea turtle scientists, local fishermen, and local ecotourism guides to conduct research with the students. A major focus of this research has been to develop and test new fishery technologies, including sea turtle bycatch reduction technologies (e.g. net illumination and auditory alerts) and electronic monitoring systems designed to help augment observer coverage specifically for small scale fisheries. Solutions first tested in the "BAHIA" program have been transferred to multiple gillnet fisheries worldwide. Eighty percent of high school students who conducted research in the BAHIA program have proceeded to graduate college and sixty percent have majored in science and conservation fields. Students who participated in the early years of the program are now attending graduate school, receiving graduate degrees, and entering the scientific workforce. We will share our program model and highlight scientific and educational successes. We are incredibly grateful to NOAA Pacific Islands Fisheries Science Center, NOAA West Coast Regional Office, NOAA Pacific Islands Regional Office, NOAA Bycatch Reduction Engineering Program, the International Seafood Sustainability Foundation, and World Wildlife Fund for their support of this work.

CLEAN URUGUAYAN SEA

Marina-Belen Reyes[1], Alejandro Fallabrino[1], Gabriela M. Veléz-Rubio[1], Andrés Estrades[1], Daniel Gonzalez-Paredes[1], Natalia S. Teryda[1], Virginia Ferrando[1], Martin Makarewicz[1]

[1]Karumbé NGO. Av. Rivera 3245, Montevideo CP 11400, Uruguay

Every year large amounts of litter is produced by daily activities. A huge part of this garbage ends up on the beaches and rocky points of the Uruguayan coast. These areas represent important feeding grounds for juveniles of *Chelonia mydas* (green sea turtle). As a consequence, this pollution affects dozens of sea turtles annually, producing severe health problems due to the ingestion of plastics or being trapped in lost fishing lines. Between 2007 and 2015, Karumbé NGO have found over 200 marine turtles potentially killed by marine debris. To face this environmental problem, the organization has been working on the campaign "Mar Uruguayo Limpio" (Clean Uruguayan Sea) since 2009. The aim of this program is to raise awareness among locals, tourists and volunteers to be responsible for litter management when visiting the Uruguayan coast. We think that environmental education plays an important role to encourage people to make decisions and take actions to reduce marine debris. In accordance with this premise, a special awareness sector was set up in the three Marine Turtle Visitor Centers operated by Karumbé NGO, located in: i) Montevideo, ii) La Paloma and iii) La Coronilla. These centers represent public spaces where the visitors and volunteers receive simple, clear and direct information (e.g: how long the garbage take to degrade, how marine debris can affect marine turtles (by ingestion, injury, drowning, etc.) or how it possible to help the turtles in this issue, recycling actions, etc). Through impressive graphic material and the use of social media networks, the organization expects to raise awareness and empower the public with the task of solving the issue of plastic pollution on the seas. In the last two years, more than 30 thousand people between 25-34 have interacted on Karumbé NGO Facebook website, sharing images, broadcasting beach cleaning events, involving more people to participate in this initiative. Since the beginning of the project “Mar Uruguayo Limpio” in 2009, the visits to Karumbé NGO Centers have increased 10% per year. During the summer season 2015-16 (December to April), 2500 people visited the center in La Coronilla, and about 1800 people visited the center in La Paloma. On the other hand, we have observed an increase in the number of volunteers. Karumbé conducts a volunteer program from December to April every year. In 2009, the total number of volunteers was 63 during the summer season. Actually, this number reaches more than 100 volunteers attending the program.

A REVIEW OF COMMUNITY EDUCATION & OUTREACH AMONG FOUR RURAL COMMUNITIES SURROUNDING SEA TURTLE NESTING BEACHES; MOST SUCCESSFUL METHODOLOGIES AND IDEAS FOR THE FUTURE

Annie Clift[1,2], Anna Hall[1], Monserrat Lopez-Agüero[1], Daniela Rojas[1], Madeleine Beange[1,2], Randall Arauz[2]

[1]CREMA Costa Rica
[2]Turtle Trax Guanacaste Costa Rica

As community education and outreach has become an increasingly popular trend to combat species degradation, especially in sea turtle conservation, continual review and research of methods and progress is necessary. This study assesses the progress, and its causes, of community outreach and education within four communities located on sea turtle nesting beaches in the Southern Nicoya Peninsula, Guanacaste,

Costa Rica. The sites: San Miguel, Corozalito, Costa De Oro and Bejuco, have been subject to seasonal community involvement efforts for the past 15 years, 9 years, 5 years, and 5 months, respectively. We review various differences amongst the communities that may contribute to the success and make conclusions on the best processes to undertake when beginning a community program. With the results, we propose a new model for community education that revolves around issues of respect and awareness. Through interviews with locals and general observation, we assessed community members with varying levels of involvement in the project sites. Several topics were discussed that included conservation and sea turtle themes, as well as community structure and history. Within all the sites a standardized interview was conducted (n=24) with a minimum of four adults and two youth per location. Other materials used in our assessment included before and after questionnaires from a teen program launched in Bejuco (n=7) and a series of interviews conducted in San Miguel (n=14). The array of materials allowed us to investigate and compare different models and their achievements. The results show that communities with stronger organization and structure, and those, which have recognized leaders, correlate as being more responsive to education and outreach efforts. When comparing poaching levels, we see a strong correlation between site maturity (and thus exposure to community programs) and percentage of nests poached per season. It is also evident that stronger and more formal programs such as the teen program in Bejuco, have better and quicker educational outcomes and growth. In addition, we evaluated levels of understanding for global connectedness and ecosystem niche importance. This was correlated with beliefs of animal welfare and behaviors of animal care as indicators of outwardly exhibited respect. With this correlation, we propose a new theory for community education revolving around teaching connectedness and using more accessible examples, such as their home and immediate surroundings, i.e. pets and gardens, to make real life learning connections of how respect can become reciprocal between nature and ourselves. A program based off this theory would focus on preliminary teachings of general respect and how our actions can affect us and our surroundings both in the immediate and future, before diving into sea turtle conservation. This allows for participants to better understand the meaning of conservation and its importance, therefore allowing us to obtain better success and progress within our community programs.

FIELD ACTIVITIES & AWARENESS PROGRAMMES FOR THE COASTAL COMMUNITIES TOWARDS SEA TURTLE CONSERVATION AT KALPITIYA PENINSULAR IN SRI LANKA

Lalith Ekanayake[1], A.M.D.S. Rathnakumara[1], Y.K. Karunarathna[1]

[1]Bio Conservation Society (BCSL)

There are five species of sea turtles that come ashore to nest in Sri Lankan beaches and their feeding and migratory routes located around the Island. The species are namely green turtle, leatherback, olive ridley, loggerhead and the Hawksbill. The coastal communities of Sri Lanka have to depend on their surrounding natural resources for their survival. Thus, many coastal habitats and biodiversity are under the threat of extinction. The coastal communities in Sri Lanka heavily exploit sea turtle populations by egg poaching. Although turtles are protected by the Fauna and Flora protection ordinance since 1972, egg poaching occurs in most of the nesting beaches. One of the least understood and possibly most serious threats that face marine turtle populations in Sri Lanka is by-catch in fishing gears. So coastal communities must be educated about the importance of conserving the sea turtles and coastal ecosystems including various habitats such as coral reefs, mangroves, sea grass beds etc. The aim and objective of these programmes was to increase the education and awareness on sea turtle biology and conservation, legislation and law enforcement on sea turtles among the coastal communities such as fishermen, school children and other coastal resource users. So far in 2016 it has conducted over 50 awareness programmes at schools and villages for the school kids and community members. An awareness poster was printed and distributed among the participants. Several field activities such as beach cleaning, mangrove replanting, school

environment cleaning and tree planting at home gardens were conducted. The community members (both adults and school children) actively participated in the above field activities and they were highly enthusiastic to do the field activities. Cashew nut and Pomegranate plants were distributed among two hundred families at Kandakkuliya village as a pilot project to motivate the community. It was very successful and now the plants are growing well. Many newspaper articles were published in three local newspapers and approximately 400,000 copies of newspapers were distributed throughout the island with the news. Therefore, a larger group has read the conservation message. Further, the community members were very happy to see publishing their field activities with their pictures. Most of the community members were very interested about the awareness programmes and got information on coastal biodiversity conservation. They understood how they benefit from conservation of coastal biodiversity including sea turtles. The active participation of coastal communities (both adults and children) increased coastal biodiversity conservation. We believe it is the major outcome and must continue more fieldworks to get more active contribution from the community.

USE OF ARTS TO CREATE AWARENESS ON SEA TURTLES IN SRI LANKA*

Thushan Kapurusinghe[1], Tharanga Herath[1], 5[1], Shayma Wijekulasuriya[1], Dhanushka Mahanama[1], Lucia Reyna[1]

[1]Sri Lanka Turtle Conservation Project

Changing people's attitudes is immensely important in conservation and management of marine & coastal resources. Awareness is globally recognized as a vital tool in changing attitudes. Conducting lectures, workshops, film shows. TV/radio programmes, exhibitions, field visits and competitions/games are some of the activities commonly used by educators to create awareness. The Sri Lanka Turtle Conservation Project (SLTCP) has been conducting various educational programmes to create more awareness on sea turtles and other marine and coastal resources such as Dugongs, seagrass meadows, coral reefs and mangroves etc. since 1993. The aim of conducting these programmes is to get more community support for conservation efforts. In September, 2015 SLTCP initiated a new project in Gulf of Mannar area of Sri Lanka to conserve important marine and coastal habitats. This project is funded by the GEF Dugong and seagrass conservation project of UNEP/CMS Dugong MoU Secretariat. As one of the project activities, SLTCP organized and conducted a national level art competition among the school children in Sri Lanka in collaboration with the Wijaya Newspapers Limited. In May 2015, a newspaper advertisement was posted in newspapers published by Wijaya Newspapers Limited using both Sinhala and Tamil languages. Advertisement was posted over a four-week period. The advert described about the rules, deadlines and awards of the school art competition. Four categories namely nursery, primary, junior and senior were established based on the age of the children. School children were asked to submit their paintings related to any theme on marine and coastal resources. In paroral to the art competition, a series of newspaper articles were published on various topics on marine & coastal resources. The deadline for submitting arts was on 30th June, 2016. During this four-week period, we received more than 3000 paintings from school children Island wide. School paintings were judged by a panel of professional artists from the Wijaya Newspapers Limited. From each category, 1st, 2nd and 3rd places were selected. In addition. 100 highly commended paintings were selected from each category. Winners were contacted and results have been informed. The award ceremony was held in Colombo on 3rd September, 2015 with the participation of a cabinet minister of Sri Lanka and many other special guests from various relevant institutions. Paintings of the winners were framed and displayed at the award ceremony venue. Both cash and non-cash awards were presented to the winners. The award ceremony received wide media coverage. During the awards ceremony, the chief guest has delivered the special speech with a valuable conservation message. Received

paintings reflect the knowledge of the students on endangered species and their interactions with other marine resources. During the awards ceremony, many students became volunteer members of the SLTCP. Many parents of the students have requested SLTCP to organize this art competition as an annual event.

MALAMA NA HONU EDUCATIONAL OUTREACH AND PUBLIC MANAGEMENT IN HAWAII

Irene K. Kelly[1]

[1]*NOAA Fisheries*

Malama na Honu ("to care for turtles"; MnH) is a non-profit community-based organization with a mission to help protect Hawaiian green turtles (honu) through education and public awareness. Since 2007, MnH has provided educational outreach to locals and visitors via the efforts of approximately 70-100 "Honu Guardian" volunteers at Laniakea Beach, on the North Shore of Oahu. MnH accomplishes its mission in the Spirit of Aloha, meaning volunteers express a positive, friendly, and joyful attitude. Hawaii is one of the only locations in the world where green turtles deliberately bask (sleep) on the beach consistently. Volunteers promote low-impact viewing practices flavored with fun and engaging facts about the 18 - 25 honu that regularly bask at Laniakea which has become known as "turtle beach" with over 600,000+ people visiting annually. The soaring popularity of ecotourism and social media means potentially harmful and disrespectful interactions between people and turtles may occur. While ecotourism can help improve public conservation awareness, it can also lead to irresponsible actions that may disturb resting or foraging turtles. The MnH Guardians deal with this contingency on a daily basis. To reduce potential harassment to basking turtles and in collaboration with NOAA Fisheries and other state and federal partners, MnH has determined that a viewing distance of 10 feet (3 meters) results in no change in a turtles' behavior, and the public can enjoy turtles while getting their desired photos. A win-win for all! It also supports our island culture which encourages viewing wild animals in their natural habitat safely and with respect. MnH also provides outreach and presentations at public events, festivals and local schools throughout Oahu and has developed materials in six languages: English, Japanese, Chinese, Korean, Spanish, and Hawaiian. Further, the basking data collected by volunteers produces a myriad of vital information about Laniakea's basking honu. For instance, data indicates that peak basking activity is during the spring (March to June), approximately two thirds of basking occurs between the hours of 11 am and 3 pm, and that many individual turtles show distinct basking frequency patterns from year to year. These data combined with the successful viewing guidance developed by MnH helps support sea turtle conservation and public management in Hawaii.

TOO RARE TO WEAR: A CAMPAIGN TO END DEMAND FOR TURTLESHELL IN LATIN AMERICA*

Brad Nahill[1], Emma Harrison[2], Paula von Weller[3], Wallace J. Nichols[4], Jose Urteaga[5], Didiher Chacón[6], Georgina Zamora[7], Stephen G. Dunbar[8], David Melero[9], Eric Ramos[9], Gena Abarca[10], Julia Azanza-Ricardo[11], Karla Barrientos[12], Cristian Ramírez-Gallego[12]

[1]*SEE Turtles*
[2]*Too Rare To Wear*
[3]*Too Rare To Wear*
[4]*California Academy of Sciences*
[5]*Stanford University*
[6]*Latin American Sea Turtles*
[7]*Sea Turtle Conservancy*
[8]*ProTECTOR Inc.*
[9]*Eastern Pacific Hawksbill Initiative*
[10]*City University of New York*
[11]*INSTEC*
[12]*Fundacion Tortugas del Mar*

Despite the significant reduction in international trade of hawksbill (*Eretmochelys imbricata*) shells and products due to their inclusion in the CITES Convention, the domestic sale of turtleshell products (also sometimes referred to as "tortoiseshell") continues to be a major threat to this species in Latin America and the Caribbean. According to recent surveys by conservation organizations in Cuba, Colombia, and Nicaragua, hawksbill shells are frequently found for sale in markets and souvenir shops. Anecdotal evidence suggests that the primary market for these products is tourists, both domestic and international. Too Rare To Wear is a new outreach campaign which aims to reduce the demand for turtleshell products by travelers to the region. The initial phase of the campaign is evaluating the current status of turtleshell commerce in the region, which will be the first regional survey since one completed in 2002. The data collected will include how many places sell the products, estimations of the number of products sold, and additional information obtained by survey questions of the sellers. This data will be collected by a large team of sea turtle researchers from around the region, primarily representatives of local organizations, covering at least 30 tourist destinations in 8 countries around the region. Additionally, researchers will investigate tourist knowledge on the issue. We will present the results of the turtleshell survey that covers parts of Belize, Colombia, Costa Rica, Cuba, El Salvador, Honduras, Nicaragua, Panama, and other locations. We will summarize the tourist research, which will be conducted by online and in-person surveys. In addition, we will share bilingual campaign outreach materials including videos, which will be freely available to any organization or individual who wants to participate in the campaign. Support for this campaign was provided by the Bently Foundation and Lush Cosmetics.

TURTLE FREE RESTAURANT CAMPAIGN*

Ryley Parent[1,2], Katherine Comer-Santos[1], Michael Heithaus[3], Elizabeth R. Whitman[3]

[1]The Science Exchange
[2]San Diego State University
[3]Department of Biological Sciences, Florida International University, 3000 NE 151st Street, North Miami, FL

The Bahamas contains five out of the seven species of sea turtles, and serves as an important foraging habitat for juvenile green turtles. Illegal hunting of juvenile turtles poses a major threat to their population numbers. This is especially important because green turtles, the primary species in Abaco, have exceptionally slow growth rates, and their age of sexual maturity is the oldest of any sea turtle species, being around 40 years old. Despite legislation, passed in the Bahamas in 2009, prohibiting the take of any part of a turtle including turtle eggs and the disturbance of turtle nests, there is still a cultural demand for turtle meat. Our ongoing approach to this issue is to get the community involved in sea turtle conservation by hanging turtle free restaurant signs in local restaurants. We launched the Turtle Free Restaurant campaign in Abaco, Bahamas during the summer of 2016. The restaurants that chose to participate receive free advertising in the form of lists published in the local newspaper and distributed to local hotels in the area. The signs promote people to dine at those establishments with the Turtle Free Restaurant signs, instead of venturing into places that still sell turtle meat. Our initial results show that the majority of the community is very interested in sea turtle conservation and the bulk of restaurants are more than willing to help with the cause. We do, however, still encounter those in opposition to the hunting ban and continue to hear rumors of restaurants selling turtle meat. To date, we have reached five communities in Abaco, with 18 restaurants hanging signs, and gathered 230$ in donations in exchange for Turtle Free Restaurant stickers designed to further the campaign. We have also distributed over 300 stickers to locals and visitors to raise awareness about this campaign. By generating awareness among locals and visitors, we hope to make an impact on Abaco by shifting business to restaurants supporting the law. In doing so, we can protect the juvenile green turtle populations that inhabit Abaco, ensuring they are able to reach sexual maturity and eventually reproduce. This campaign has a very broad target audience and because we are able to reach a large variance of people with these signs the word is easily spread that illegal turtle hunting still happens despite law enforcement. Turtle Free Restaurants can be used as a model campaign that we hope to expand to other countries where similar turtle hunting happens, giving us the opportunity to protect many turtle populations for generations to come.

ABOUT TURTLES AND FUTURE: EDUCATING CHILDREN TO THE AWAKENING IN SCIENCE AND PRESERVATION

Camila Poli[1,2], Karine Gonçalves Cabreira Birnfeld[2], Caroline Crestani Jung de Assis[1]

[1]Colégio Marista Ipanema, Porto Alegre, Rio Grande do Sul, Brazil
[2]Colégio Murialdo, Porto Alegre, Rio Grande do Sul, Brazil

Research involving the knowledge and preservation of sea turtles is increasingly advanced. But who will be the researchers of the future? Who will be interested in continuing the work already done? Certainly those who were encouraged to love animals and to be curious about them. Those who were awakened to environmental problems and, since childhood, had a notion of their role as a citizen of this planet. Because

of this, environmental education of children focused on knowledge and the preservation of species is increasingly necessary. Children are easily stimulated through playfulness and the use of imagination. Environmental education work is often put at a lower level than technical research, but it is essential to ensure the continuity of preservation work. This project was performed for six months with 48 children from 5 to 8 years old, in the city of Porto Alegre, located about 95km from the southern coast of Brazil. These children go to the coast only during the school vacations and therefore have no proximity to the marine environment. To arouse interest, a beach replica was built in their classrooms where we simulate the entire life cycle of a sea turtle, including the threats faced by these animals. Initially the children imagined it was a real turtle egg, but even after finding out it was not a true animal, they kept their interest in the project, since they were already fully involved with the proposal. In partnership with the teachers of these children, we form a multidisciplinary team and work on concepts of sustainability and preservation. Through resources such as images and videos we pass information about species, the life cycle and threats. Each week we modified the fictitious beach according to the information that had been passed on and at this time the children should interfere and make the right decisions for the turtle's survival and for the environment balance. Through play, the children, within their imagination, perceived themselves as turtles and observed how difficult is the life of an animal which gets tangled in debris. The children were encouraged to practice low consumerism with their families because they were very shocked by the debris effect on the turtles. They were also surprised to discover that global warming represents a threat to turtles and that all of us, as part of the problem, could also collaborate to mitigate this impact. In addition, mathematical and language contents were studied from information about sea turtles, such as size of each species, number of eggs in nesting, threats and locations where species are found. At the end of the project, children who already knew how to write made a little book about sea turtles, in order to tell what they learned to others. The seed of care and of curiosity has been planted and many of these children already consider themselves scientists researching ways of preserving turtles. In view of the success obtained with the project this year, we intend to expand and carry it out continuously.

CREATING AWARENESS TO PROTECT ENDANGERED SEA TURTLES AND THEIR HABITAT IN SRI LANKA

Lucía Reyna[1], Thushan Kapurusinghe[1], Tharanga Herath[1], Shayma Wijekulasuriya[1], Himali Kahawita[1], Dhanushka Mahanama[1]

[1]Sri Lanka Turtle Conservation Project (SLTPC)

Sri Lanka Turtle Conservation Project (SLTCP) is a dedicated NGO that conducts research, surveys, education & awareness programs, community based conservation and management programs to achieve the sustainable level of sea turtle populations in Sri Lanka. Since its establishment in 1993, as part of the conservation projects of sea turtles that we had conducted in the country, we had established different environmental educational programs with the aim to create and raise awareness to protect endangered sea turtles in Sri Lanka. The educational programs had been conducted to approach different stakeholders; from small kids to elder people, as the people of higher status in the Government as well. Even though the conservation projects are conducted in a specific area, we have been able to approach people from different communities and people in general from other parts of the island. To expand the environmental education to more people in the country, we had published articles in a Sri Lankan Newspaper called Mawbima and also participated in educational programmes broadcasted by the National Radio Channel ITN FM. We also conducted different educational exhibitions and published Newsletters to achieve more publicity. Our NGO has been dedicated to perform research and conservation programs with sea turtles, but also we are committed with the conservation of coastal and marine ecosystems in general; and with the species that are part of it. As part of this commitment to protect coastal and marine ecosystems, SLTCP has been one of

the partners of the GEF Dugong and Seagrass Conservation Project since 2015. This project is executed by the Mohamed bin Zayed Species Conservation Fund, with financing from the GEF, implementation support by UNEP and technical support from the CMS Dugong MoU Secretariat. The Dugong project is based in Kalpittiya, at the North-western coast of Sri Lanka in the Puttlam District. The Puttlam lagoon, the second largest lagoon of the country, is located in this area. One of the main objectives of the Dugong and Seagrass project is to raise awareness about the management of marine and coastal resources; so the lectures and film shows conducted as part of this project, had also been used to send a message to conserve endangered sea turtles. One of our biggest achievements was the declaration of a sanctuary of nesting green turtles in Rekawa in 2006, at the south of the country. Our research projects conducted for more than 20 years, gave enough scientific sustenance, but our programs of environmental education conducted to people of the area and to high-ranking politicians, also empower this achievement. The three main target groups of the programs conducted in 2015 and 2016 were public in general, school children and fishermen. We will continue expanding our acknowledgement regarding conservation throughout the country because we truly believe that environmental education is the biggest tool to change thoughts and attitudes in order to conserve the coastal and marine ecosystems.

ECONOMIC AND EDUCATIONAL OUTREACH PROGRAMS IN EQUATORIAL GUINEA*

Elizabeth Sinclair[1], Gertrudis Ribado[2], Frank V. Paladino[1], Shaya Honarvar[1]

[1]Indiana University - Purdue University Fort Wayne
[2]Universidad Nacional Guinea Ecuatorial

"Alternative livelihood" and education programs can be valuable tools for conservation. One of the goals of Bioko Marine Turtle Program in Equatorial Guinea is to provide alternative occupations and sources of income to people in the coastal villages of Bioko Island, where sea turtles nest, thereby decreasing the level of local threats to species and habitat. Four species of sea turtle nest on Bioko Island; hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) turtles. The southern beaches of Bioko support the second highest nesting densities of both leatherback and green turtles in the Gulf of Guinea (A total of 43,860 leatherback and 16,778 green turtle encounters since 2000). Three community outreach programs have been created which includes, an artisanal crafts and sales effort, training and employment of local villagers as sea turtle patrol assistants, and a multifaceted education and conservation program. The program is designed to deter the take of endangered sea turtles and their eggs from nesting beaches by providing novel, sustainable revenue streams to the coastal villages of Equatorial Guinea, thereby decreasing local reliance on revenue generated from take. Development and implementation of a multifaceted conservation education and outreach program for elementary schools, local communities, and university students is focused on increasing awareness about sea turtles and about biodiversity conservation as a whole. These programs have resulted in increased awareness about sea turtles, increased revenue generation, and increased self-esteem in the home (especially for women, who have a new avenue to contribute to household income) and in the community.

RIDING THE WAVE OF ED-TECH: DEVELOPING A FAR-REACHING STEALTH EDUCATIONAL AND AWARENESS TOOL*

Anna Stamatiou[1], Emelia Jones[2]

[1]MEDASSET
[2]The Lucky Lot

In common with countless conservation organisations worldwide, MEDASSET had, until now, concentrated its educational effort on the communication of information about sea turtles… their biology, life cycle, and the threats they face both on land and in the water. An obvious difficulty with this model, which typically requires the leading/facilitating presence of a 'knowledgeable authority' figure, is that it is self-limiting in terms of the size of the audience it is possible to reach. MEDASSET's ambition is to speak to more people, so, although an online tool cannot hope to reach communities experiencing significant economic deprivation, we chose to explore its potential for finding a larger audience. However, not only the issue of numbers is at stake: underlying the traditional approach is the rationale that the more knowledge a target group (in our case principally young people) has about a given environmental challenge – such as the continued survival of sea turtles in the Mediterranean – the more likely it is to modify its behaviours in ways that will act to mitigate the problems. However, progress in the understanding of the drivers of behaviour change indicates that this paradigm is increasingly being called into question. People may know something is bad or damaging – and even understand exactly why – but nevertheless persist with their problem behaviours. MEDASSET re-examined its education strategy and decided to develop an online tool that will not only reach a larger and more diverse audience but also follow at least some of the principles that have been shown to encourage people to modify their behaviour, namely: "Show me others doing it; make it social; make it convenient; make it fun". To that end, MEDASSET engaged "The Lucky Lot", a Dublin-based design practice that put together a custom team of game development specialists. Working collaboratively, we designed and realised an online game that allows players imaginatively to enter the marine environment and, via a sea turtle avatar, to care for it and populate it with living organisms. We included elements that provide challenges to dexterity and creativity while also engaging the emotions. Within the game arena, behaviour that acts to protect sea turtles and their habitats is rewarded, while accurate information about them is stealthily communicated to players as the game unfolds. The flow of information goes both ways, since valuable data about players, e.g. their age and location (but not their identity), can be collected and used to inform the game's further development. We will explain the rationale behind the inclusion of individual elements of the game, and set out our ideas for expanding what has already been realised locally to an international scale, so that new "Marine Scenes"" - currently tailored to the Mediterranean region - can be created in partnership with organisations working around the world to conserve sea turtle populations in, indicatively, the Caribbean, Indian Ocean or Eastern Pacific, as well as other RMUs.

ADVERTISING CAMPAIGN AND FOUND RAISING "SAY CHEERS FOR THE SEA TURTLES"

Pablo Antonio Trujillo-Susunaga[1], Lucia Rosendo-Herrera[1]

[1]*Ayotzintli*

The need to seek new ways to raise awareness about the problem of sea turtles, coupled with the constant need to find new ways to raise funds, led Ayotzintli to create a pair of styles of Handmade Beer, which were named Lora and Siete Filos in honor of the endemic species of Mexico (L*epidocheys kempii*) and one of the species threatened and charismatic of the planet (*Dermochelys coriacea*); Within bars and restaurants position the issue of sea turtles and in turn have an effective way to get resources to support turtle camps. This campaign, which has been developed in more than 50 localities in 7 states of Mexico, has made it possible to impact through posters, small conferences and leaflets to more than 5000 people directly in the year that has been implemented, in addition to through networks Social have reached more than 10000 people giving the importance of our country; In these efforts have been raised to raise more than 3000 usd that have been used to support community conservation projects of sea turtles in the Mexican Pacific. In the next year, the goal is for a community to be the producer of beer, after training of experts, thus closing the productive circle for the benefit of the conservationists of Mexico.

Fisheries and Threats

SEA TURTLE BYCATCH IN GILLNET FISHERIES: A COMPARISON OF CATCH RATES AND SIZE CLASSES FROM SAN JOSE, NORTHERN PERU

Nicolas Acuña-Perales[1], Astrid Jiménez-Heredia[1], Sergio Arturo Pingo-Paiva[1], Joanna Alfaro-Shigueto[1,2,3], Jeffrey C. Mangel[1,2]

[1]ProDelphinus. Lima, Perú
[2]University of Exeter, United Kingdom
[3]Universidad Científica del Sur. Lima, Perú

Five sea turtle species are found in Peru and, together with marine mammals and sea birds, their populations are affected by bycatch in small-scale fisheries. The estimated number of sea turtles captured annually in Peru is likely in the tens of thousands. Differences in the type of gillnets (surface and demersal) and mesh size (small size: < 4.75 in; and large size: > 5 in) could have an impact on the catch rates and sizes of captured turtles. We compared the sizes (CCL) and bycatch rates of green turtles (*Chelonia mydas*) captured during 70 fishing trips conducted between January 2013 and October 2016 in San Jose, northern Peru. A total of 221 green turtles were captured during the study period. For the entire study period the mean CCL of green turtles captured in surface driftnets was 56.6 ± 1.2 cm (range: 40.0 - 84.7 cm; n=158), while in bottom set nets the mean CCL was 56.6 ± 1.9 cm (range: 46.6 - 85.6 com; n=53). Based upon the minimum CCL of nesting females (60.7 cm) from the Galapagos Islands, approximately 25% (n=52) of captured turtles could be classified as adults. Our results suggest that the sizes of bycaught green turtles do not vary considerably by year or between superficial and bottom gillnets. However, 74.9% of green turtle captures were in superficial gillnets and 25.1% in bottom gillnets. Also, the vast majority of captures (91.5%) occurred in large mesh nets, with only 6.6% occurring in small mesh sizes, and 1.9% in unspecified mesh sizes. This study provides valuable information on green turtle catch characteristics, but this data comes from only one fishing port. We recommend expanding the study to other ports in northern Peru to assess at a larger scale the implications of the bycatch of green turtles in gillnet fisheries.

SEA TURTLE BY-CATCH REDUCTION IN GHANA'S GILLNET FISHERY*

Andy Agyekumhene[1], Phil Allman[2]

[1]University of Cape Coast
[2]Florida Gulf Coast University

Sea turtles have a significant ecological role in marine and coastal ecosystems, but their ecological functions are currently threatened due to the reduction of populations throughout the globe. The primary risk to their survival comes from the marine environment where they are routinely challenged with entanglement or capture in commercial and artisanal fisheries. Although it is illegal to capture sea turtles in Ghana, the incidental capture of these animals remains a major threat to turtle populations in the region. Gear illumination has been reported to reduce sea turtle by-catch (Wang et al. 2010, 2013). We examined the potential effectiveness of illuminating gillnets with Green Light-Emitting Diodes (LEDs) for reducing sea turtle interactions in Central Region of Ghana. Trained observers were placed on 20 fishing vessels to document by-catch during 2016. Ten boats were equipped with LED lights and the remaining 10 served as a control. Forty-nine sea turtles were captured in the control nets and 13 turtles were captured in the

treatment group. This demonstrates a 41.1% reduction in sea turtle captures in the illuminated nets. We did not find any significant difference in overall catch rate of target fish. Market value of fish catch between LED fitted nets did not differ significantly from net without LEDs. We conclude that illuminated nets are effective at reducing sea turtle by-catch while maintaining overall target fish captures in Ghana's gillnet fisheries.

MAN VERSUS MACHINE: ELECTRONIC MONITORING VERSUS ON-BOARD OBSERVERS IN SMALL-SCALE FISHERIES IN PERU*

David Bartholomew[1], Jeffrey C. Mangel[1,2], Joanna Alfaro-Shigueto[1,2,3], Sergio Arturo Pingo-Paiva[1], Astrid Jimenez[2], Brendan J. Godley[1]

[1]University of Exeter, Penryn, Cornwall, UK
[2]ProDelphinus, Lima, Peru
[3]Universidad Cientifica del Sur, Lima, Peru

Small-scale fisheries impact greatly on the populations of threatened marine fauna. Peru's small-scale elasmobranch gillnet fishery captures thousands of sharks and rays each year, as well as high rates of incidental capture of sea turtles, small cetaceans and pinnipeds. We assessed the ability of cameras to identify and quantify catch in this fishery by comparing its performance to observer reports. Cameras were installed across five boats with a total of 139 fishing sets monitored. The cameras were shown to be an effective tool for identifying catch, with > 90% detection rates for 9 of 11 species of elasmobranch caught. Detection rates of incidental catch were much lower (sea turtle = 73%; cetacean = 67%). The camera's ability to quantify target catch degraded with quantity and smaller species. Cameras were more effective at quantifying rays than sharks. We showed cameras can provide a more time- and cost-effective method to monitor small-scale fisheries and can be used to overcome deficiencies in observer reports. However, cameras are not yet sufficient to effectively monitor bycatch. With modifications to the camera specifications, we expect their performance to improve for all catch species.

FISHERY AS ADMINISTRATIVE UNIT: IMPLICATIONS FOR SEA TURTLE CONSERVATION*

Bruno de Barros Giffoni[1,2], Gilberto Sales[3], Nilamon O. Leite Jr.[3], Mariana de Karan e Britto[1], Fernando N. Fiedler[4], George Olavo[5]

[1]Fundação Pró-TAMAR. Rua Antônio Athanazio da Silva, 273, 11680-000, Jardim Paula Nobre, Ubatuba, SP, Brasil.
[2]Universidade Federal da Bahia. Programa de Pós Graduação em Ecologia e Biomonitoramento. Rua Barão de Geremoabo, 147, Campus de Ondina. CEP: 40170-290 Salvador - Bahia
[3]Centro TAMAR/ICMBio. Av. Ministro Victor Konder, 374, 88301-700, Itajaí, SC, Brasil
[4]CEPSUL/ICMBio. Av. Ministro Victor Konder, 374, 88301-700, Itajaí, SC, Brasil |
[5]Universidade Estadual de Feira de Santana. Departamento de Ciências Biológicas, Laboratório de Biologia Pesqueira, Avenida Transnordestina, s/n - Novo Horizonte. CEP 44036-900 - Feira de Santana - Bahia.

The pelagic longline fishery in Brazil started in the mid-fifties. This fishery uses different gear configuration and strategies to catch swordfish, sharks, tunas and mahi-mahi. However, the gear configuration and

strategies adopted to catch those target species seems to also affect the incidental capture of sea turtles. If the fishing gear configuration and strategies change according to target species and if these changes affect the sea turtle incidental capture, the national and regional fishery management organizations - RFMOs (e.g. ICCAT) should divide the longline fisheries according to its own characteristics to better understand the incidental capture of sea turtles, their causes and consequences. Nevertheless, this approach has not been used and, usually, pelagic longline fisheries have been analyzed as a unique administrative unit, as being homogeneous when affecting the biota. Here, according to their characteristics (i.e. target specie, hook type, bait type, spatial distribution, float line length, branchline length, etc), we divided the Brazilian pelagic longline fishery in five distinct fisheries and compare the relative composition of sea turtle species and size class captured by each ones. Therefore, each pelagic longline fishery was understood as the administrative unit to monitor, assess and mitigate the interaction among sea turtles and fisheries. This approach (named here as "fishery approach") is clearly distinct from that one used by the national fishery management organizations and RFMOs. To perform the analyses we used the information from Projeto Tamar's database (The National Sea Turtle Conservation Project) and considered only commercial longline trips monitored by onboard observers between 1999 and 2016. This data comprise more than twenty million hooks sampled mainly in the South Western Atlantic Ocean. The results show significant differences for sea turtle species composition, as well for the size classes captured by distinct longline fisheries. Considering that sea turtle species have distinct threatened status and that each sea turtle species interacts differently with each longline fisheries, as shown in this work, the fishery approach proposed here essentially helps to prioritize conservation actions by sea turtle species and by type of longline fisheries. This fact has important implications for sea turtle conservation as well as for the fishing management. Finally, we recommend adopting "fishery" as an administrative unit to monitor, assess and mitigate the incidental capture of sea turtles in longline fisheries.

POPULATION THREATS TO HAWAIIAN HAWKSBILL SEA TURTLES REVEALED FROM THREE DECADES OF STRANDINGS*

Shandell Brunson[1,2,3], Kyle S. Van Houtan[4], Stacy Hargrove[1,2], Thierry Work[5,6,7]

[1]NOAA
[2]NMFS
[3]MTBAP
[4]Monterey Bay Aquarium
[5]USGS
[6]NWHC
[7]HFS

Hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) are the most common species of marine turtles in nearshore Hawaiian waters; however, green turtles outnumber hawksbills by over an order of magnitude. The low population numbers has led researchers to suggest that the Hawaiian hawksbill population is one of the smallest known marine turtle populations. While greens were historically plentiful throughout the archipelago, little is known about the historic abundance and distribution of hawksbills. To gain a better understanding of the magnitude and distribution of threats facing hawksbills, we analyzed stranding data collected in the Hawaiian Islands between 1984 and 2014. Strandings of sick, injured, or dead turtles on all islands were reported to the NOAA Marine Turtle Research Program, presently known as the Marine Turtle Biology and Assessment Program. In this study, we synthesize these records to evaluate the basic trends in time, demographic composition, and distinguish the type and mortality of various threats. In doing so, we present a comprehensive description of the population across developmental stages and rank threats that may be impeding the successful recovery of the population. Over

the 33 years, there were 88 hawksbill sea turtle strandings in the Hawaiian Islands ranging in size class from juvenile to adult (15-89 cm SCL). We classified threats into categories representing typical injuries facing Hawaiian hawksbills. Wounds related to fishing gear were by far the most prevalent threat and cause of death. The second prevalent cause of death was emaciation. Stranded turtles of known sex were female biased (female = 36; male = 5) suggesting sex-specific threats or possibly nesting location and sand temperatures are affecting sex-ratios. It is evident there is a particularly small hawksbill population in the Hawaiian Islands from the small number of strandings and in comparison with the number of green turtle strandings over the same time span. Future studies are needed to focus on the foraging ecology of hawksbills to understand possible resource limitations as well as conservation and research efforts to mitigate anthropogenic threats in Hawaii.

ANALYSIS OF MICROPLASTIC ABUNDANCE AND INFLUENCE ON NEST TEMPERATURE FOR OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS OLIVACEA*) ON PLAYA SAN MIGUEL AND PLAYA BEJUCO, GUANACASTE, COSTA RICA

John Brzoza[1], Annie Clift[1], Randall Arauz[1]

[1]CREMA & Turtle Trax S.A., San Francisco de Coyote, Costa Rica

The presence of microplastic in marine litter has been well-documented across many beaches throughout the world, but a knowledge gap remains regarding the extent to which microplastic can impact beach characteristics and dependent marine life. In particular, much is unknown about how nesting sea turtles and their clutches are influenced by concentrations of microplastic on nesting beaches. This research aims to examine these influences by studying plastic litter and nesting Olive Ridley sea turtles (*Lepidochelys olivacea*) on Playa San Miguel and Playa Bejuco, Guanacaste, Costa Rica. A spatial analysis of plastic litter on Playa San Miguel was conducted by sifting sand from artificial nests dug 40 centimeters deep and recording the amount of plastic found in 10-centimeter increments. To sample a larger beach area the procedure was then repeated, recording only total amounts of plastic found. Sampling revealed microplastic to be found along the entire beach and at every depth up to 40 centimeters. The increment from which the most microplastic was collected was 11-20 centimeters. To study the influence of microplastic on incubation temperatures, the core nest temperatures of artificial nests dug inside of a hatchery were analyzed. HOBO temperature loggers were placed in nests containing varying amounts of microplastic, and the temperatures were recorded for two sets of data loggers over the course of 36 days and 23 days. During the period of time representing the second trimester (days 15-36) of incubation, the mean temperature for all nests, regardless of amount of microplastic, was above the documented pivotal temperature of 30.5 °C for Olive ridleys. Over this same period of time, a general trend of lower mean temperature and lower maximum temperature for nests with greater microplastic abundance was observed. Future studies will focus on the critical nest temperatures for sex differentiation and clutch survival, with specific regard to Olive ridleys, as a method to better understand the effects of microplastic on future sea turtle populations.

GEOSPATIAL ASSESSMENT OF ARTIFICIAL LIGHTING IMPACTS ON SEA TURTLES IN TORTUGUERO, COSTA RICA

Nerine Constant[1,2]

[1]Nicholas School of the Environment, Duke University, Beaufort, NC, USA
[2]Archie Carr Center for Sea Turtle Research, University of Florida, Gainesville, FL, USA

Artificial lighting on sea turtle nesting beaches discourages adult females searching for nest sites and disrupts hatchling seafinding behavior, with potentially substantial effects on nesting activity and hatchling survival. Because artificial light on nesting beaches has the potential to impact sea turtle life history stages that are essential to reproductive success, managing artificial lighting is a critical component of nesting beach protection. Tortuguero Beach in Costa Rica supports the largest green turtle (*Chelonia mydas*) nesting population in the Western Hemisphere, and the Sea Turtle Conservancy (STC) has monitored and worked to protect the nesting population since 1959. The primary objective of this project was to support the Sea Turtle Conservancy's efforts by 1) assessing the effect of artificial lighting from adjacent development on green turtle nesting activity on Tortuguero Beach and 2) mapping artificial lighting on the beach to identify the brightest areas as appropriate targets for light pollution reduction efforts. I conducted walking surveys to map the nesting beach and brightness surveys during the new moon to measure luminance at 50-meter intervals along the beach. The Sea Turtle Conservancy provided counts of nests and false crawls by mile section. I identified mile sections experiencing light pollution and examined the relationship between brightness and nesting activity. Nesting activity decreased as mean luminance increased, and there were significantly fewer emergences of nesting females from the sea in mile sections experiencing light pollution. Results of this study indicate that artificial lighting from adjacent development affects green turtle use of nesting habitat, supporting the need for a turtle-friendly lighting initiative in Tortuguero.

ASSESSING GAS EMBOLISM RISK IN BY-CAUGHT SEA TURTLES FROM TRAWLING AND GILLNET FISHERIES*

Jose Luis Crespo-Picazo[1], Andreas Fahlman[1], Blair Sterba-Boatwright[2], Brian A. Stacy[3], Daniel García-Párraga[1]

[1]Fundación Oceanografic de la Comunidad Valenciana, Gran Ví-a Marques del Turia 19, 46005 Valencia, Spain
[2]Texas A&M University-Corpus Christi, 6300 Ocean Drive, Corpus Christi, TX, 78412, USA
[3]National Marine Fisheries Service, Office of Protected Resources, University of Florida, College of Veterinary Medicine (duty station), Post Office Box 110885, Gainesville, FL, 32611, USA

By-catch is as a major global threat for sea turtle populations. A recent study showed that by-caught turtles can experience decompression sickness caused by gas embolism (GE). It is hypothesized that the stress associated with being by-caught disrupts the normal physiology and increases nitrogen uptake while submerged. Elevated blood and tissue nitrogen tension increases the probability of gas bubble formation. The severity of GE appears to correlate with the clinical signs of decompression sickness and outcome. Post-interaction mortality resulting from gas embolic disease may be significantly underestimated. External signs can be minimal or unapparent initially or may be masked by response to capture or concomitant metabolic/respiratory disbalances after forced submersion, only to worsen upon release. Diagnostic imaging is required to reliably detect GE. Most turtles that develop moderate and severe GE will die without

hyperbaric treatment based on observations in turtles admitted for care. We analyzed data from 128 by-caught loggerhead turtles that were evaluated for the presence of GE, examining relationships between occurrence of GE, turtle size (carapace length), body mass, and the type and depth of gear deployment. The severity of GE was evaluated on a scale from 0 to 5, based on the relative amount and distribution of gas visible by ultrasonography and radiography. The data were analyzed using logistic and ordinal regression to examine risk factors associated with GE in sea turtles captured in trawls and gillnets. Preliminary results show that the probability of fatal GE increases with increasing depth of gear deployment. This evidence of a direct relationship between depth, risk and severity of GE has not been previously demonstrated for any diving species. Our findings are critical for accurate estimation of sea turtle mortality resulting from different fisheries and for devising efforts to avoid or minimize the harmful effects of capture.

TESTING THE ABILITY OF METAL DETECTORS TO FIND RECREATIONAL HOOKS INGESTED BY JUVENILE SEA TURTLES

Marina Cucuzza[1], Susan G. Barco[1], Sarah A. Rose[1]

[1]*Virginia Aquarium & Marine Science Center*

The unintentional capture of sea turtles in fishing gear is recognized as a significant source of mortality for these species. Efforts to better understand and reduce the impact of fishery interactions are a high priority in the research and conservation efforts of sea turtles (Barco and Swingle, 2014, Lewison et al., 2014, Moore et al., 2009). Sea turtles generally interact with hook and line gear by becoming externally hooked and/or entangled, or by ingesting the hook and bait. Efforts to better understand incidental sea turtle bycatch have largely focused on commercial pelagic longline fisheries (Stokes et al. 2011). Sea turtle interaction with the recreational hook and line fishery, however, is not well understood (NMFS 2009, NMFS & USFWS). The Virginia Pier Partner Program was established by the Virginia Aquarium Stranding Response Program (VAQS) as a pilot project in 2014 in response to an increase in incidental sea turtle bycatch in recreational hook and line gear. Turtles that were hooked at fishing piers are taken to the Virginia Aquarium's Marine Animal Care Center (MACC) for hook removal and rehabilitation. Radiographs from animals hooked at fishing piers revealed the presence of additional hooks in 16% of cases. In an effort to reduce expensive radiographs, we investigated the efficacy of hand-held metal detectors. Three metal detectors were tested to determine their ability to detect the presence of hooks ingested by sea turtles. The Adams Electronics Scanner ER 3000®, Garret Pro Pointer AT®, and the Garrett Super Scanner Wand V® were tested using hooks recovered from sea turtles. Average detection distance of bare hooks was determined for circle, J, and treble hooks ranging from 10-85 mm in length. Hook detection distance was compared against hook length, width, and weight. The Adam's Electronics metal detector had the greatest average detection distance in comparison to the two other scanners regardless of hook length, weight, or width of metal. Experimental trials were also conducted to evaluate the ability of metal detectors to detect hooks through the body of a sea turtle. Hooks were placed in the mouth, esophagus, and stomach of a juvenile green turtle carcass (SCL N-N=27.6cm). In these trials, the Adams Electronics metal detector was the only model that was able to detect the presence of hooks in every location tested, including through the carapace. The detectors were then tested on a live loggerhead that was hooked at a fishing pier (SCL N-N=54.0cm). None of the metal detectors were able to detect three hooks in the esophagus revealed in radiographs. This study demonstrates that hand-held metal detectors have different detection distances when tested with small metal objects such as hooks. An ultra-sensitive detector such as the Adams Electronics metal detector may be the only effective way to detect the presence of some recreational hooks and only in smaller (<28cm SCL-NN) juvenile sea turtles. Future testing will determine the size limit of turtles and hooks that can be detected as well as detection error rates with different users.

ALARMING TRENDS ON PLASTIC INGESTION IN LOGGERHEAD SEA TURTLES IN THE SOUTH WEST INDIAN OCEAN

Joseph Dando[1], Claire Jean[1], Mathieu Barret[1], Stéphane Ciccione[1]

[1]*Kélonia*

Plastic debris is now ubiquitous in the world's oceans, and affects all types of marine habitats, but their impact has yet to be fully understood. Sea turtles are known to ingest or get entangled in plastic debris, resulting in a large range of injuries, and in more rare cases in death. Moreover, plastic is also suspected to cause various sub-lethal effects, such as dietary dilution, absorption of toxins, or reduced fertility, which can lead in the long-term to an aggravated problem for turtle's survival. Because of the high ingestion rates of plastics of loggerheads sea turtles, the Marine Strategy Framework Directive identified *Caretta caretta* as an indicator to evaluate the good ecological status of French waters. In the South-West Indian Ocean, Kelonia's care center has been surveying plastic ingestion in loggerheads sea turtles since 2007. Those turtles were rescued after being accidentally captured by local longline fisheries around Reunion Island. The care center treated them and hosted them until their rehabilitation and release in the ocean. Among the 167 loggerheads received from 2007 to 2016, 121 (72%) had ingested plastic. During the first weeks or months of their captivity, loggerhead turtles defecated the debris they had previously ingested: 94% of them were plastic items. These debris were collected, counted, categorized by type and colour, and also weighed and measured. A total of 5528 debris (mean: 52 ± 54) was collected for a total weight of 2115 g (mean: 20 g ± 19g). Maximum length of debris collected ranged from 1 to 1450 mm (mean: 28 ± 40). Hard fragments and white plastics were predominant among the sample: 90% and 40% respectively. The results also revealed an increase in the occurrence frequency of plastic debris ingestion in loggerhead turtles ranging from 33% in 2007 to 84 % in 2016, representing a 6% increase each year. This increase was also observed in the weight of plastic debris with 1,6g annually. Seasonal variations were also observed in the ingestion rate of marine debris over the study period. Those results underline high levels of plastic debris ingestion in loggerheads compared to other regions (i.e. Mediterranean) and reveal an important increase over the years. They confirmed the importance of addressing plastic issues. Further investigation is still needed to infer their impact on loggerhead turtles in terms of sub-lethal effects and diseases, starting with contaminant concentration analyses.

TRENDS IN SEA TURTLE BYCATCH FOLLOWING THE IMPLEMENTATION OF AN INCIDENTAL TAKE PERMIT IN NORTH CAROLINA ESTUARINE WATERS

Brianna Elliott

[1]*Duke University*

Bycatch in commercial fisheries is a primary threat to sea turtle populations worldwide. In North Carolina, juvenile loggerhead, green, and Kemp's ridley sea turtles are incidentally caught in the commercial gillnet fishery for flounder, which operates in the same estuarine waters that are vital foraging grounds for several sea turtle species. In 2010, the Duke Environmental Law and Policy Clinic filed suit on behalf of the Karen Beasley Sea Turtle Rescue and Rehabilitation Center against the North Carolina Division of Marine Fisheries (NCDMF) and North Carolina Marine Fisheries Commission (NCMFC) for exceeding sea turtle take limits under Incidental Take Permit (ITP) #1528 in the Pamlico Sound, NC, as well as taking sea turtles without a permit elsewhere in inshore gillnet fisheries. Because sea turtles are listed as endangered pursuant

to the Endangered Species Act, these takes violated federal law. As part of a 2010 settlement agreement, NCDMF applied for an ITP under the Endangered Species Act, which was issued in 2013 and authorized species-and-ara- specific bycatch levels in the commercial gillnet fishery each year. We analyzed trends in sea turtle bycatch compared to fishery landings and fishing effort for six years since the settlement (2010 to 2016) to understand how the conditions of the settlement and ITP have affected bycatch, fishing effort, and commercial landings. We also analyzed observer coverage throughout the fishery and show how variations in observer coverage affect the number of observed and estimated turtle takes. Building on these results, we discuss how the conditions of the ITP have affected turtle bycatch reduction over the past three years. Finally, we make recommendations for improvements to the ITP to better protect turtles based on this analysis.

STRANDED TURTLES IN CANARY ISLANDS, A LONG - TERM STUDY

Andrea Fariñas-Bermejo[1], Patricia Ostiategui-Francia[1,2], Ana Liria-Loza[1,2]

[1]University of Las Palmas de Gran Canaria
[2]EcoAqua institute

Canarian waters are very important for marine animals, including sea turtles such as green turtles (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*), coming from different rookeries (USA, Mexico and Cape Verde). Between those two species, the loggerhead presents the highest stranding rate, which produces that all along the year a great number of sea turtles are attended by the wildlife recovery center (WRC) of each Island. The data collected from the stranded turtles, both alive and dead, are an important source of information about the threats that sea turtles have to face in the wild. So, the aim of this study is to analyze the temporal and spatial stranding fluctuations over several years, using the data collected by the different wildlife recovery centers. The results show a change in the main threats for marine turtles along the years, which give us the possibility to develop different action plans at the different threat levels. Furthermore, during the data compilation from the different WRC, the importance to implement a standard methodology for data collection was evinced.

ISLAND VS. PREDATOR: USING BIOSTATISTICAL AND GIS ANALYSIS TO DEVELOP A RESEARCH-BASED PREDATOR CONTROL PROGRAM FOR NESTING BEACHES UNDER ATTACK

Jaynie L. Gaskin[1], Tara Lopez[1], Gale A. Bishop[1], R. Kelly Vance[1], Linda Smith[1]

[1]Georgia Southern University Sea Turtle Program at St. Catherines Island

St. Catherines Island, located off the coast of Midway, Georgia, USA has 21 km of loggerhead sea turtle (*Caretta caretta*) nesting habitat monitored from 1989 to the present by the Georgia Southern University Sea Turtle Program at St. Catherines Island (GSUSTP@SCI). Sea turtle nests on St. Catherines Island (SCI) face two major threats: washover of nests due to erosion caused by sea level rise and predation of nests by feral hogs (*Sus scrofa*) and raccoons (*Procyon lotor*). During the 2016 nesting season, St. Catherines Island had the highest percentage of predated nests out of all sea turtle nesting beaches on the entire Georgia coast. Nearly 40% of all sea turtle nests on SCI were lost to predators. A total of 127 nests were affected, the highest incidence of predation in the island's history. Sea turtle conservation efforts on St. Catherines Island must evolve to include an active and aggressive predator control program. The purpose of this study is to

use biostatistical and GIS techniques to analyze predation events on St. Catherines Island from 1999-2016. The ultimate goal of this project is to identify biostatistical and spatial relationships among predation, environmental and nesting variables in order to develop a research-based predator control program. Although this project focuses on predation events and related variables, it will also serve as a pilot study for a broader longitudinal analysis of environmental and nesting data from 1999-2016. Nesting data from 1999-2008 were obtained from field books and entered into Microsoft Excel. Nesting data from 2009-2016 were downloaded from SeaTurtle.org as Activity Reports and Loss Reports. The two data sets were cleaned, merged in Microsoft Excel and then exported into SPSS biostatistical software and ArcGIS mapping software. Within SPSS and ArcGIS, predation, environmental, and nesting data were recorded into appropriate variables for biostatistical and spatial analysis. In SPSS, demographic and frequency analyses were conducted to identify possible associations among predation, environmental and nesting variables. Odds ratios and 95% confidence intervals were calculated to investigate all associations. In ArcGIS, Kernel Density, Optimized HotSpot, and Cluster and Outlier analyses were conducted to observe concentrations for loss counts (incidents), total egg losses, and lost nest counts per year. The Average Nearest Neighbor and High/Low Clustering analyses were calculated to determine statistical significance. Predation, environmental, and nesting data from 1999-2016 were successfully cleaned, and merged into one complete data set in Microsoft Excel. The data set was imported into SPSS and ArcGIS for analysis. Analysis of data produced statistically significant results that will be used to design and implement a research-based predator control program. Results of this research will improve sea turtle conservation efforts not only on St. Catherines Island, but also on nesting beaches worldwide. This study highlights the need for further biostatistical and spatial analysis of the interactions among predation, environmental, and nesting variables for applied use in sea turtle conservation.

FISHERY AND GARBAGE ARE ALSO CONSIDERED THE MAJOR THREATS AGAINST SEA TURTLES ON THE COASTLINE OF ANGRA DOS REIS AND PARATY, RIO DE JANEIRO STATE, BRAZIL

Humberto Mas Gitirana[1], Gisele Lôbo-Hajdu[1]

[1]*Laboratório de Genética Marinha da Universidade do Estado do Rio de Janeiro (UERJ). Instituto de Biologia Roberto Alcântara Gomes, Departamento de Genética (DGen), Rua São Francisco Xavier, 524, Pavilhão Haroldo Lisboa Cunha (PHLC), sala 205, Maracanã (20550-013), Rio de Janeiro, RJ, Brasil*

Sea turtle populations are declining all around the world. In Brazil, the five species occurring on the coast are also considered threatened of extinction. Besides of natural causes, several anthropogenic activities can affect the life of these animals, increasing much more the mortality index: egg collection and hunting, habitat destruction by coastal zone occupation, vehicle traffic on the beaches, ocean pollution, incidental capture by fisheries etc. The PROMONTAR-ANGRA Project, supported by the Eletrobras Eletronuclear Nuclear Power Plant Company, was developed to study and monitors the stranding occurrences of sea turtles over the coastline of Angra dos Reis and Paraty, south of Rio de Janeiro State, Southeastern Brazil. The aim of this work was to investigate the possible causes and associations of death of stranded sea turtles founded on the beaches during a period of three years. From July 2013 to June 2016, through public callings (tourists, fishermen and others), stranded turtles were systematically rescued (dead or debilitated) along this region. Histopathology and necropsy analysis were done to evaluate the possible causes and associations of death of these animals. A total of 213 turtles were rescued, 142 (67%) dead and 71 (33%) debilitated. Except one, all of other turtles founded debilitated were led to veterinary treatment on PROMONTAR ANGRA. Of these debilitated, 46 (65,7%) died during rehabilitation process, 18 (25,7%) were rehabilitated and released back to the sea and 6 (8,6%) still kept in treatment. Finally, 188 dead sea turtles were recorded: 101 (54%) were directly buried because of poor carcass conditions, and 87 (46%) were taken to necropsy.

After necropsy, on 18 cases (21%) were not possible to evaluate the cause of death and were considered inconclusive. Of the 69 remaining, the causes of death were identified as: respiratory collapse on 26 cases (30%); toxic-endogenous shock on 14 cases (16%); parasitism on 12 cases (14%); septicemia on 10 cases (11%), chronic process on four cases (5%), neurogenic shock and pneumothorax on one case (1%). It was also registered only one case of euthanasia procedure (1%). All necropsy and histopathology technical reports were stored as documental memory. Necropsy results point to the major cause of death as being respiratory collapse and toxic-endogenous shock, respectively. The respiratory collapse cases are generally associated with incidental capture by fishery, when turtles get trapped underwater and didn´t reach the surface to breath. So, it suffers a long time of apnea, drown, and consequently lead to death. The toxic-endogenous shock cases are associated with situations when sea turtles ingest numerous marine debris (garbage) that causes blockages within digestive system and dehydration, and consequently lead to death. These data indicate that garbage and fishery represent the major threats against sea turtles on the coastline of Angra dos Reis and Paraty, reinforcing the magnitude of these problems for sea turtle survival all around the world.

PHYSIOLOGICAL DISTURBANCES ASSOCIATED WITH SEA TURTLE BYCATCH IN SOUTHERN BRAZIL: PRELIMINARY RESULTS

Daphne W. Goldberg[1,2], Karina Flaiban[1], Caiame Nascimento1, Luiz Rodrigo Maçaneiro de Leão[1], Mariana de Karan e Britto[3], Gilberto Salles[1], Camila Trentin[1], Daniel Wagner Rogério[1], Juçara Wanderlinde[1], Bruno de Barros Giffoni[4]

[1]Fundação Pró-TAMAR. Rua Professor Ademir Francisco s/n. Barra da Lagoa
[2]Universidade Estadual de Londrina. Departamento de Medicina Veterinária Preventiva, Centro de Ciências Agrárias. Rod. Celso Garcia Cid (PR 445), Km 380. Caixa Postal 10.011. CEP: 86057-970- Londrina- PR- Brasil
[3]Centro TAMAR/ICMBio. Av. Ministro Victor Konder, 374, 88301-700, Itajaí, SC, Brasil
[4]Universidade Federal da Bahia. Programa de Pós Graduação em Ecologia e Biomonitoramento. Rua Barão de Geremoabo, 147, Campus de Ondina. CEP: 40170-290 Salvador - Bahia

Sea turtle bycatch in different types of fishing gear may cause high rates of post-release mortality, contributing to the rapid decline of endangered populations. Turtles that survive incidental capture may present sublethal effects such as physical injuries, physiological disturbance as well as behavioral and reflex impairment. This study is part of Tamar´s initiative to reduce sea turtle bycatch and aims to evaluate the physical and physiological conditions of sea turtles immediately after being caught in three different types of gear: longline (targeting mahi-mahi), trawling and pair trawling. However, samples are still being processed and for this reason, only preliminary results are presented. Blood samples were withdrawn from the dorsal cervical sinus of eleven turtles, from which eight were *Caretta caretta*, two were *Chelonia mydas* and one was *Lepidochelys olivacea*. Six loggerheads were captured in longline and two in pair trawling; one green turtle was captured in pair trawling and one in trawling and the only olive ridley was captured in longline. All turtles captured were immature, with CCL between 40 and 81 cm (68.2 ± 11.91). The three individuals captured in pair trawling (two loggerheads and one green turtle) showed symptoms of drowning (lethargy, respiratory deficiency and foam in nares and mouth) and two of them died on board, a *C. caretta* and a *C. mydas*. Blood chemistry analyses revealed higher serum lactate (mean = 30.56 ± 4.86 mmol/L; N = 3) and glucose (mean = 224.33 ± 58.15 mg/dL; N = 3) levels for drowned turtles, especially for the ones that died on board. This might be explained by the fact that capture by trawling leads to forced submergence, which requires increased anaerobic metabolism, producing higher levels of lactate (for gluconeogenesis). Moreover, bycaught turtles struggle to get back to the surface to breathe and both, physical and physiological stress may prompt an increase in blood sugar. On the other hand, longline-captured

individuals exhibited lower serum lactate (mean = 13.82 ± 5.30 mmol/L; N = 8) and glucose (mean = 113.14 ± 23.47 mg/dL; N = 8) levels if compared to pair trawling-captured turtles. Turtles captured by shallow-set longline also struggle to escape, however, sometimes they are capable of surfacing to breathe, while hooked. This is particularly true for turtles captured by longlines targeting mahi-mahi, like the ones from this study, once the gear is set to work very close to the surface. If the turtles were caught by longlines targeting tuna, the results would probably be different. No significant differences in serum ion levels were observed among bycaught turtles. The preliminary results presented here suggest that lactate and glucose serum levels might be used as biochemical predictors of delayed mortality of captured sea turtles. Additionally, under trawl conditions, the turtle must recover from any physiological disturbance before it is released back into the water.

DOES RECREATIONAL DIVING IMPACT HAWKSBILL SEA TURTLE FORAGING BEHAVIOR? RESULTS FROM A MARINE PROTECTED AREA, HONDURAS*

Christian T. Hayes[1,2,3], Dustin S. Baumbach[1,2], David Juma[4], Stephen G. Dunbar[1,2,5]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR), Loma Linda, CA 92350, USA
[2]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA 92350, USA
[3]Department of Science and Mathematics, Judson University, Elgin, IL 60123, USA.
[4]School of Public Health, Research Consulting Group, Loma Linda University, Loma Linda, CA 92350, USA
[5]Protective Turtle Ecology Center for Training, Outreach, and Research Inc., Honduras (ProTECTOR - H), Tegucigalpa, Honduras

Recent studies indicate that recreational diving may cause unintended behavioral changes in marine macrofauna. The hawksbill sea turtle (*Eretmochelys imbricata*) is a critically endangered species encountered pantropically by recreational divers in marine protected areas (MPAs). No other studies to date however, have examined the impacts of recreational diving on sea turtle behavior. We conducted in-water observations of 61 juvenile hawksbill turtles from June 12 to September 2, 2014 in the Sandy Bay West End Marine Reserve (SBWEMR), Roatán, Honduras, to quantify impacts of recreational diving on hawksbill behavior. We recorded turtle behaviors and the number of behavioral bouts to test the effects of diver approach on sea turtle behavior. As a control for diver interactions, we began all observations by recording turtle behavior for approximately 3 – 5 min. To test if diver approach affected a change in turtle behavior, we instructed different sized groups of divers (1 - 4) to slowly approach each turtle. We used the Interactive Individual Identification System (I3S): Pattern (Version 4.0.1) to test for repeat individuals. To test for associations between behavioral bouts and behavior time, we ran Spearman's correlations. We also ran repeated measures ANCOVAs, comparing the total time turtles engaged in each behavior before and after divers approached turtles. Our results for 1027.3 min of observation time indicated the amount of time turtles engage in eating (16.5%), investigating (16.3%), and breathing (4.0%) activity was highly correlated with the number of behavior bouts of each behavior. We also found the mean time turtles spent eating (2.2 ± 0.5 min) and investigating (2.2 ± 0.4 min), as well as the median time turtles spent breathing (0.5 ± 0.1 min), decreased when approached by divers. Our results suggest diver habituation may negatively impact sea turtle eating, investigating, and breathing behaviors, however, it is unknown if recreational diving has a cumulative effect on turtle behavior over time. We recommend that MPA managers implement monitoring programs that assess the impacts of dive and snorkel tourism on sea turtles. In our study, we established monitoring of hawksbills, which have the potential to be heavily impacted by dive tourism, as a representative species of reef inhabitants. Furthermore, we provide specific recommendations for continued

monitoring of sea turtle populations in other MPAs, recognizing the importance of accounting for diver impacts during in-water studies.

THE STRANDING NETWORK IN TAIWAN*

I-Jiunn Cheng[1], Wan-Hwa Cheng[2]

[1]*National Taiwan Ocean University*
[2]*Arizona State University*

Operation of sea turtle stranding network is important for the conservation of sea turtle and marine environment. Nearshore water is the critical habitat for most sea turtles. The long-term records can identify how many species inhabit there, demographic information such as gender, size and possible age distribution, spatial and temporal distribution etc. It cans also determine possible causes of stranding through the necropsies and veterinary medical treatments. The combine of above information with nearshore pollution and weather allows us to demonstrate the importance of coastal conservation to both human and endangered species such as sea turtles. In Taiwan, sea turtle stranding network has established since 1997. Due to the public un-awareness and lack of veterinarian assistant in the first 15 years, we only received on average 9 reports each year. The cooperation of this network with the Dean, School of Veterinary Medicine, National Taiwan University, active campaigning of sea turtle stranding network by Forestry Bureau, Council of Agriculture and public awareness, the reports increased to 105 in 2015 and 136 for the first 10 months in 2016. 19 years records showed that almost 80% stranded turtles was greens, and 55% belonged to adolescent (i.e. 35 to 55 cm CCL). The main stranding seasons are fall to winter and spring, when the seasonal change is significant. Among stranded turtles, almost40% was by-catched and 50% stranded on the coast. The “hot spot” of stranded sites are I-Lan County, NE of Taiwan and New Taipei County, Northern Taiwan. 35% stranded turtles are alive. More than 90% was rescued in the early phase of stranding and rehabilitated well. We conducted satellite telemetry on one rehabilitated mature female hawksbill turtle and set the record of longest track ever done in Taiwan; more than 5000 km. Most stranded turtles, dead or alive, contained certain amount of anthropogenic waste, stress the threat of coastal pollution to the survivorship of this endangered species.

HOOKED ON HONU: DOCUMENTING THE HARMFUL EFFECTS OF NEARSHORE FISHERY INTERACTIONS WITH HAWAIIAN SEA TURTLES AROUND THE ISLAND OF MAUI (2004-2016)

Cheryl King[1], Tara Branham[1], Anita Wintner[1], Don McLeish[1], Tommy Cutt[1], Miranda Camp[1]

[1]*Hawai'i Association for Marine Education and Research*

A total of 184 sea turtles directly affected by fishing gear were documented around the island of Maui, HI from 2004-2016 through the authors’ field observations (n=65), a network of personal contacts (n=98), volunteering with the National Oceanic and Atmospheric Administration Sea Turtle Stranding Program (n=16), and online (n=5). Seven cases, two of which were fatal, involved endangered hawksbills (*Eretmochelys imbricata*, known as “honu’ea” or “‘ea”). The remaining 177 cases involved threatened green turtles (*Chelonia mydas*, known as “honu”), 19 of which had fibropapilloma tumors. When size classes could be determined (n=156), 64.1% of the cases involved juveniles and 35.9% were adults (64.3% were females and 35.7% were males). The majority of these observations were of turtles in their marine

environment (n= 157), with an increasing number of basking greens (n=27). Of the 72 cases involving visible hooks, 25.0% were hooked in the front flippers and 2.8% were hooked in the rear flippers, indicating these were the most purely accidental interactions. The turtles' shoulders were hooked in 12.5% of the cases, and 19.4% were hooked in the neck, also indicating that these may have been accidental snags. The majority (36.1%) was hooked in the mouth and 4.2% was hooked in the face region, demonstrating that these turtles were likely intentionally foraging on the baited hooks. Taking these 29 turtles and adding an additional 38 cases in which turtles were observed having line going into their mouths, but no hook was visible, leads to the presumption that, at a minimum, 67 (36.4%) out of the total 184 hooked/entangled cases were likely bait-driven and not accidental. Thirty-seven of these hooks were identified as being used when pole fishing for large jacks, or "ulua". Fishing line affected 151 of the 184 turtles, many of which had multiple entangled appendages. The most common entanglement locations were the shoulders (50.2%), mouth/face (25.5%), neck (19.5%), front flippers (2.6%) and then the rear flippers (2.2%). The severity of fishing line entanglements was recorded when possible: 66 cases had tight wraps and 22 of these, exhibited swollen/necrotic tissue. Eight turtles were missing front flippers due to the self-amputation effects from losing blood circulation. One turtle had the ~15" spear portion of a 3-prong protruding from its neck. It is known that these interactions represent a significant threat to sea turtle survival, and these observations are merely a fraction of the total cases that actually occur. A total of 89 "Good Samaritan" rescues were made. Due to the physical resilience of sea turtles, no further medical attention was necessary for most of the turtles, but many conditions would've likely worsened if not helped. At least 75 (40.8%) of the cases would have benefited from further medical treatment: 38 with ingested line/hooks, 22 with necrotic appendages and 15 with embedded gear directly affecting their survival. This does not include the eight greens whose flippers had already self-amputated, which emphasizes the need for an official specialized marine response team, a sea turtle rehabilitation facility on Maui and more community awareness.

STRANDED LOGS ON THE BEACHES OF GABON - A MAJOR THREAT TO NESTING SEA TURTLES

Carmen Karen Kouerey Oliwina[1], Pierre Didier Agamboue[1], John Pedro Agamboue[1], Eric Augowet Bonguno[2], Francois Boussamba[3], Floriane Cardiec[1], J. Michael Fay[2], Angela Formia[1], Brendan J. Godley[4], William F. Laurance[5], Brice Didier Koumba Mabert[6], Cheryl Mills[4], Gil Avery Mounguengui[7], Carine Moussounda[6], Solange Ngouessono[2], Jacob Nzegoue[1], Richard J. Parnell[1], Guy-Philippe Sounguet[2], Bas Verhage[8], Lee White[2], Matthew J. Witt[4], Stephen K. Pikesley[4]

[1]*Wildlife Conservation Society*
[2]*Agence Nationale des Parcs Nationaux*
[3]*Aventures Sans Frontières*
[4]*University of Exeter*
[5]*James Cook University*
[6]*Centre National des Donnees et des Informations Océanographiques*
[7]*Ibonga*
[8]*WWF*

Gabon is a little known country on the Atlantic coast of Africa, hosting what is believed to be the largest leatherback (*Dermochelys coriacea*) nesting population in the world, and the largest nesting population of olive ridleys (*Lepidochelys olivacea*) in the Atlantic. In addition to its rich marine biodiversity, Gabon is also covered by as much as 85% of rainforest. As a consequence of forestry operations in the country's interior, whole logs are often lost in transport along waterways, estuaries and at sea. Many of these logs wash up on the beaches, creating a serious source of threat to sea turtles. Adult females may become jammed among logs and perish. On other occasions, logs block access to the drier upper beach, forcing females to

nest below the high tide line or to make extensive deviations along their tracks. Logs buried beneath the surface affect nest-building, nest depth and beach composition, while emerging hatchlings may become disoriented by logs blocking their vision and access to the sea, and increasing vulnerability to predation. We have collected data on the distribution, abundance and impact of logs on Gabon's beaches since 2003; and our records show that by 2011 more than 17,000 logs were stranded along the coastline, with higher densities in the northern Pongara National Park. Within this park, we have focused on the beach with the highest leatherback nesting density and have found that as many as 17% of all nesting events were impacted by the presence of logs. Additional data on fine-scale distribution of logs between 2011 and 2016 will be presented, as well as the results of substantial log removal operations. Despite our efforts, stranded logs remain a persistent threat to sea turtle survival in Gabon, and additional funding is being sought to engage in wider-scale removal efforts.

IMPACTS OF HARMFUL ALGAL BLOOMS ON A CENTRAL FLORIDA DEVELOPMENTAL HABITAT*

Christopher A. Long[1], Céline Mollet-St. Benoît[1], Ryan M. Chabot[1], Kendra Cope[1], Katherine L. Mansfield[1]

[1]*Biology Department University of Central Florida Orlando FL USA*

The Indian River Lagoon (IRL), located along Florida's central Atlantic coast, provides important developmental habitat for juvenile green sea turtles (*Chelonia mydas*) and loggerheads (*Caretta caretta*). In recent years, this lagoon system has experienced an increased incidence of harmful algal blooms. These blooms are known to diminish water quality and negatively impact an ecosystem's structure and function. In 2011-2013, a "superbloom" consisting of two separate bloom events severely impacted the IRL. Dramatic footage of fish kills, marine mammal die-offs, and bright green algae covering the lagoon surface during the superbloom focused national attention on the degraded status of the IRL. However, unlike other taxa, marine turtle strandings did not increase during the superbloom, suggesting that the effects of the bloom were sublethal. We hypothesized that, due to the extensive seagrass and drift algae die-offs caused by the bloom, juvenile marine turtle abundance in the IRL would decrease and those that did remain would have decreased body condition during the bloom. To test these hypotheses, we used a model selection approach consisting of 49 total models, including zero-inflated and negative binomial-based generalized linear models, to examine 11 years (2005-2015) of in-water sea turtle capture data at the University of Central Florida's long-term IRL study site. Over the 11 years, 277 capture sessions were conducted, 1,569 juvenile green turtles and 432 juvenile loggerheads were captured. Depending on whether interactive effects of the bloom and seasonal variation were accounted for, the eight top green turtle models indicated moderate to strong evidence that green turtle captures decreased during the bloom and remained lower after the effects of the bloom had subsided. Similarly, green turtle body condition decreased during the bloom and remained lower after bloom conditions subsided. On the other hand, loggerhead captures and body condition did not decrease during the bloom and increased after the effects ended. We hypothesize that these differential impacts were due to differences in the foraging ecology of the two species and how the superbloom affected their food resources. Further study is needed to determine whether turtles changed their foraging ecology during the bloom, either through changes in diet or by moving to new habitats. The ecological impacts of harmful algal blooms are negatively affecting juvenile green turtles in the IRL, and managers and regulators should take this into account when developing strategies to prevent or limit future blooms.

TARTALIFE PROJECT: IDENTIFICATION OF THE BYCATCH HOT SPOTS AREAS AND IMPLEMENTATION OF RELIABLE MITIGATION DEVICES IN MEDITERRANEAN SEA*

Alessandro Lucchetti[1], Massimo Virgili[1], Claudio Vasapollo[1]

[1]CNR-ISMAR

The loggerhead sea turtle (*Caretta caretta*) regularly inhabits the Mediterranean basin, where incidental catch due to fishing activities is considered as the major threat for its conservation, being responsible of more than 130,000 capture events and probably over 40,000 deaths per year. Nevertheless, present knowledge about the interaction of sea turtles with fishing gears and the mitigation measures implementation are still flimsy to hamper the decline of turtle populations in the Mediterranean. In this complicated scenario, where fisheries are multispecies, multi-gears, multinational and so highly diversified, TartaLife project (LIFE12 NAT/IT/000937) aims to develop successful strategies for sea turtles conservation relying on the identification of possible areas of bycatch hotspots and finally the introduction of mitigation measures, such as fishing gear modification through Bycatch Reducer Devices (BRDs) or alternative fishing gears. Two complementary approaches have been adopted. The first is a theoretical approach based on developing models that can predict the identification of areas and periods at high risk of trawl-turtle interaction. Telemetry data from tagged sea turtles, fishing effort data from vessel monitoring systems (VMSs) and interview data from fishermen's perspective were combined to predict potential trawl turtle interaction hotspots and periods. Once the areas and periods of possible trawl-turtle interaction have been identified, several BRDs differentiating per fishing métier have been disseminated among Italian fishermen. Considering fishermen reticence to change the gear traditionally used, determining the optimal gear configuration to minimise the loss of commercial catch and avoid turtle captures, was the main issue of this practical approach. TartaLife tested: (*i*) in the pelagic longline fishery - circle hooks replacing the traditional ones (J-hooks), reducing the possibility of hook ingestion (*ii*) in bottom trawl fishery - a TED (*FLEXGRID prototype*) consisting in a particular grid made of an alloy of high strength plastic material, that made this device more manageable and more resistant than the models tested previously, (iii) in fixed net fishery – visual deterrents illuminating gillnets with ultraviolet light (LED-UV) altering turtle visual cues and alternative fishing gears consisting in collapsible fish pots. Preliminary experimental sea cruises showed that every device tested, affected neither technical performances of the gear nor the catch; bycatch reduction was instead evident. In conclusion, the synergy of the two approaches described, can be considered as a reliable mitigation strategy for sea turtle conservation in the Mediterranean.

MULTIPLE THREATS ANALYSIS FOR LOGGERHEAD TURTLES IN THE SOUTHWEST ATLANTIC

Maria A. G. dei Marcovaldi[1], Laura Prosdocimi[2], Alejandro Fallabrino[3], Bruno de Barros Giffoni[1], Andrés Estrades[3], Alessandro dos Santos[1], Paulo H. Lara[1], Thais Pires[1], Danielle Monteiro[4], Manjula Tiwari[5], Alan B. Bolten[6], Milagros López-Mendilaharsu[1]

[1]Fundação Pró-Tamar, Brazil
[2]Coordinación de Gestión de Pesquerí-as, Dirección Nacional de Planificación Pesquera, Subsecretarí-a de Pesca y Acuicultura, Argentina
[3]Karumbé NGO, Uruguay
[4]NEMA e EcoMega, Universidade Federal do Rio Grande, Brazil
[5]NOAA - Marine Turtle Ecology & Assessment Program, Southwest Fisheries Science Center, La Jolla, California, USA
[6]Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida

The southwest Atlantic (SWA) is an area of development, feeding and reproduction of loggerhead turtles. The major nesting areas are located in southeastern and northeastern Brazil. During this part of the life cycle females and hatchlings are mostly threaten by intense coastal development. Mark-recapture data and satellite tracking studies showed that female loggerheads that nest on beaches of Brazil migrate to multiple foraging areas off the coast of South America. In addition, juvenile loggerheads are mainly found along the slope and oceanic waters off southern Brazil and Uruguay. Both adults and juveniles are subject to a high fishing pressure from multiple fisheries that operate throughout coastal and oceanic environments. To better understand and quantify main impacts to loggerhead populations in the SWA we conducted a threat analysis. Our analyses were modified from the study conducted by Bolten et al. (2011). Threats were identified and classified for the different life stages and ecosystems inhabited by the sea turtles. For the construction of the matrix we considered 8 life stages: nesting females, eggs, hatchlings, juveniles neritic, juvenile oceanic, adult neritic, adult oceanic. We grouped all identified threats into six main threat categories: fisheries bycatch, resource use (direct and indirect use), habitat alteration, pollution, species interaction and climate change. Additionally, as threats vary depending on the ecosystem inhabited by the turtles, we incorporated three environments: 1) terrestrial (beach), 2) neritic and 3) oceanic. Annual mortality was estimated for each life stage/ ecosystem, with respect to each specific threat. As the information is very heterogeneous and it is difficult to assign actual mortality rates we used a range of mortality values based on the best available information (e.g. published data, projects database information and expert opinion). Mortality range estimates were classified as follows: 0 (no evidence of mortality); >0 (mortality has been documented or is likely to occur; however data are insufficient to estimate mortality); 1 -100 (low mortality); 100-1000 (medium mortality); >1000 (high mortality). Sublethal effects for certain threats and life stages were also highlighted in the spreadsheets. Results pointed out that fisheries bycatch (i.e. longline, trawl and gillnets) represent a major threat for loggerheads in the SWA, with the trawl fishery as the main source of mortality for neritic juvenile and adult turtles. In addition, egg and hatchling stages are subject to mortality by beach erosion and light pollution respectively. However, loggerheads in the SWA should be considered as entirely conservation-dependent, because the reduced mortality for several life stages within the terrestrial zone is the result of decades of intense conservation programs, especially at nesting sites.

ECOLOGICAL AND SOCIAL IMPLICATIONS OF A TIME-AREA CLOSURE FOR LEATHERBACK TURTLE CONSERVATION*

Julia G. Mason[1]

[1]*Stanford University Hopkins Marine Station*

The California Drift Gillnet Fishery (DGN) for swordfish and sharks has been a subject of considerable regulatory efforts due to its high rates of bycatch, particularly of the endangered Pacific leatherback turtle (*Dermochelys coriacea*). In 2001, the US National Marine Fisheries Service implemented the Pacific Leatherback Conservation Area (PLCA), a 200,000 mi2 seasonal closure, which has been credited with reducing leatherback bycatch in the DGN from mean 2 observed individuals annually from 1990-2000 to nearly zero. However, no study to date has explicitly examined the broader ecological and social outcomes of this large time-area closure for the DGN and California Current ecosystem. Using 25 years of onboard observer data, we examined patterns of fishing effort and catch species composition before and after the implementation of the PLCA. The PLCA has been associated with reducing the overall number of active vessels in the fishery and concentrating fishing effort south of the closure, in the southern California bight. Perhaps as a result of this geographic shift, species composition of catch and bycatch in the fishery has also changed, with reduced catch per unit effort (CPUE) of leatherback turtles, short-beaked common dolphin (*Delphinus delphis*), elephant seals (*Mirounga angustirostris*), California sea lions (*Zalophus californianus*), and blue sharks *(Prionace glauca*), and increased CPUE of sunfish (*Mola mola*), long beaked common dolphin *(Delphinus capensis*), and northern fulmar (*Fulmarus glacialis*). Among target species, there was a decrease in CPUE of swordfish (*Xiphias gladius*) and an increase in CPUE of common thresher shark (*Alopias vulpinus*) and shortfin mako shark (*Isurus oxyrinchus*). This study reveals unintended "winners" and "losers" associated with the PLCA, and may provide guidance for ecosystem based management for sea turtle bycatch in other fisheries.

TRADITIONAL KNOWLEDGE REDUCTION OF TURTLE ENTANGLEMENT IN GILLNET FISHERIES BY ADOPTING*

Muhammad Moazzam1

[1]*WWF-Pakistan*

There is an important tuna gillnet fisheries in Pakistan which employ more than 700 traditional fishing boats. It was estimated that annually about 24,000 olive ridley and 4,800 green turtles used to get entangled in pelagic gillnets with a mortality of about 3.1 %. Fishermen were persuaded to safely release the enmeshed turtles which resulted in reduction of mortality to about 2.5 %. In addition, fishermen were motivated to use methods which may reduce enmeshment of marine turtles in their net. The fishermen progressively adopted the use subsurface gillnet (locally known as "teelo") and also avoiding areas known for high turtle concentration. Use of these two measures has resulted in a major reduction in the enmeshment and mortality. About 76 % reduction in use of traditional gillnet (locally known as "bither") has been achieved in a period of two years. This has resulted in substantial reduction in the enmeshment of both olive ridley and green turtles. It is now estimated that annually about 6,300 turtles including 5,200 olive ridely and 1,100 green turtles get entangled in tuna gillnet fishery of Pakistan as well as a reduction in mortality to only 0.7 % is also achieved. In the paper, analysis of the observer data of last four years is analyzed to

elucidate spatial and temporal reduction in turtle enmeshment and mortality in coastal and offshore waters of Pakistan.

FIRST REPORT OF BOAT STRIKES ON RESIDENT SEA TURTLES IN MABUL ISLAND, SABAH, MALAYSIA

Jiun Lang Phu[1], Pushpa Palaniappan[1]

[1]Borneo Marine Research Institute, Universiti Malaysia Sabah

This is the first investigation of boat strike incidents on sea turtles at a foraging site in the Asian region, and highlights a novel injury index to assess and rank the severity of injuries caused by boat strikes on green turtles (*Chelonia mydas*). This baseline study was conducted to determine the effects of boat strikes on the green turtles found in the waters of Mabul Island, Sabah, Malaysia. From March 2013 to May 2016, 318 individual turtles were captured and 37 boat strike injuries were recorded on 33 turtles. The dominant type of the boat strike injuries were the 'straight cut wounds' (68%), followed by 'parallel cut wounds' (13%), 'deep incised wounds' (11%), and 'blunt force wounds' (8%). As for the severity of boat strike injuries, the number of injuries with 'propeller cuts found on soft tissues' (head, flippers, and tail) and 'sliced penetrating wounds on the carapace' were higher than other types of injuries. The frequencies of each injury severity was not proportionate ($\chi 2 = 12.784$, df = 5, p = 0.025). Our results show that the green turtles found in the waters of Mabul Island are susceptible to collisions with boats, where 10.4% from the total number of captured turtles exhibited signs of boat strike injuries. As motorised boats are the main mode of transportation in Mabul Island, we recommend that boat speed in close proximity to the island be reduced for the safety of all marine organisms plying these waters**.**

DEVELOPMENT AND TESTING OF NOVEL LOW-FREQUENCY ACOUSTIC DETERRENT DEVICES TO REDUCE SEA TURTLE BYCATCH

Wendy E. D. Piniak[1], John H. Wang[2], Jacob Isaac-Lowry[3], Antonio C. Figueroa[3], Sarah C. Alessi[3], Joel Barkan[4], Shara Fisler[4], Yonat Swimmer[2]

[1]Department of Environmental Studies, Gettysburg College, Gettysburg, PA 17325 USA
[2]Pacific Islands Fisheries Science Center, NOAA Fisheries, Honolulu, HI 96818 USA
[3]FlyWire Cameras, Inc., Lexington, KY 40509 USA
[4]Ocean Discovery Institute, San Diego, CA 92109 USA

Bycatch of sea turtles in fisheries in the U.S. and around the globe has been identified as a significant threat to the recovery of sea turtle populations. Coastal net fisheries are often associated with high levels of sea turtle bycatch as they frequently overlap with important sea turtle foraging habitats, mating grounds, and migratory corridors. Because of this interaction, there is an urgent need to develop tools to reduce sea turtle bycatch in these coastal fisheries. The use of acoustic alerts within the sea turtle auditory range has recently been shown to reduce sea turtle interactions with coastal nets. Due to the lack of commercially available acoustic deterrent devices (ADDs) in the low frequency range of turtle hearing, previous studies utilized speakers hung at depth connected to a floating waterproof case containing a digital player, battery, and amplifier. However, designing a compact, miniaturized, and fully submersible ADD that produces low frequency sounds is a necessary first step in fully testing the utility of a low frequency ADD in any fishery. To address these needs we initiated the engineering process by developing and testing such an ADD. The

newly developed ADDs were compact, submersible, and field tested to depths of up to 10m. Each device was 220mm in diameter, 180mm in length, and weighed 4.51kg. The electronic components were encased in durable and impact resistant PVC and ABS housings. This size allowed for quick and efficient deployment as well as easy retrieval from fishing gear, and represented a 91% reduction in size (by volume) from the previous devices. Open source software allowed the user to customize the acoustic cue (volume, frequency, and presentation rate). The ADDs were equipped with a rechargeable internal battery with the capacity to support up to 12-hour deployments. To examine the impact of these newly developed ADDs on green sea turtles (*Chelonia mydas*) and target fish catch rates we used previously established methodologies (paired experimental ADD and control nets) in Bahía de Los Angeles, Baja California, Mexico. The ADDs generated previously examined acoustic cues (alternating 200 and 400 and 300 and 500 Hz tones, 1 second in length, presented every 10 seconds at 139dB re: 1 μPa at 1m), and were placed every 20 meters along the net. We observed a 55% reduction in sea turtle catch rate in experimental nets equipped with active ADDs when compared with control nets (6 paired trials) and no difference in fish catch rate between experimental and control nets (8 paired trials). Our preliminary results suggest these low-frequency submersible ADDs may be a useful technological tool in reducing sea turtle bycatch in coastal fisheries and that further research and development of acoustic bycatch reduction strategies for sea turtles are warranted.

KEMP'S RIDLEY (*LEPIDOCHELYS KEMPII*) BYCATCH IN MISSISSIPPI, COMPARING ANGLING METHODS WITH CATCH DATA*

Eric E. Pulis[1], Andrew J. Heaton[1], Mystera M. Samuelson[1], Alicia M. Carron[1], Melissa Cook[2], Jonathan L. Pitchford[3], Debra P. Moore[1], Moby Solangi[1]

[1]*IMMS*
[2]*NOAA Fisheries*
[3]*MDMR*

Since 2012 there have been over 1,000 reports of sea turtle interactions with hook-and-line fisheries in Mississippi, with the Kemp's Ridley (*Lepidochelys kempii*) being the predominant species reported. As part of ongoing mitigation efforts the Institute for Marine Mammal Studies (IMMS) provides veterinary care and rehabilitates these turtles for return to the Mississippi Sound. Each interaction event is characterized in relation to angling methods by recording the fish species targeted, gear, and bait used. Although that data helps researchers to understand what these turtles are caught on, there is little information available to determine if turtles are selecting for, or against, any particular methods. To fill in these data gaps, IMMS surveyed anglers at established points of recorded turtle interactions during the known turtle capture season to provide a comparative data set. Over 80% of anglers approached were willing to participate in the survey. The average angler was fishing for no particular species of fish with shrimp as bait, while most turtle captures were caught by anglers targeting drum using fish for bait. Hook type usage was similar between turtle bycatch and angler survey data. Radiographs were evaluated and turtles were monitored during rehabilitation. Hooks from prior interactions were observed on radiographs in about 12% of the *L. kempii*. Of the hooks that were ingested and were not removed during the initial evaluation, 73.2% passed successfully. The data presented here can be used to inform management decisions aimed at reducing the severity of sea turtles taken in recreational fisheries bycatch.

SPATIAL DISTRIBUTIONS OF SEA TURTLE NESTS IN RELATION TO ARTIFICIAL LIGHTING IN ST. KITTS, WEST INDIES

Jessica L. Reynolds[1], John C. Maerz[1], Kimberly Stewart[2,3], Nathan P. Nibbelink[1], Steven B. Castleberry[1], Callie A. Veelenturf[4]

[1]Warnell School of Forestry and Natural Resources University of Georgia Athens Georgia United States of America
[2]St. Kitts Sea Turtle Monitoring Network Basseterre St. Kitts West Indies
[3]Ross University School of Veterinary Medicine Center for Conservation Medicine and Ecosystem Health St. Kitts West Indies
[4]Department of Biology Indiana University-Purdue University Fort Wayne Fort Wayne Indiana United States of America

Light pollution associated with coastal development is a widely recognized threat to sea turtle populations. In addition to causing disorientation in hatchlings, artificial lighting poses a threat to sea turtles because it can deter females from nesting in suitable areas and increases nesting in less-suitable but unlit habitats. St. Kitts in the northeastern Caribbean Sea is an important nesting area for the endangered green (*Chelonia mydas*) and critically endangered hawksbill (*Eretmochelys imbricata*) sea turtles and St. Kitts has had a significant rise in tourism-related development. Our goals are to determine whether: 1) light pollution levels on St. Kitts beaches are positively correlated with the probability of a false crawl and are negatively correlated with sea turtle nest density; 2) there is a threshold level of artificial light pollution above which no sea turtle nesting is observed; and 3) there are longer-term spatial trends indicating effects of coastal development on the number of sea turtle nests. In 2016, we used GIS data to quantify development along coastal beaches and we measured light pollution using a Unihedron Sky Quality Meter. We are modeling beach light levels as a function of development and correlating those measurements with nest survey data from the St. Kitts Sea Turtle Monitoring Network (SKSTMN) for hawksbill and green adult female emergence events collected from 2010 to present. Our ultimate goal is to inform management decisions to minimize coastal light pollution and development impacts on sea turtle nesting.

ASSESSMENT OF FISHERIES INTERACTIONS WITH EAST PACIFIC LEATHERBACK TURTLES AT FORAGING GROUNDS OFF THE COASTS OF COLOMBIA AND PANAMA

Juan M. Rodríguez-Baron[1], Alexander Tobon-Lopez[1], Marino E. Abrego[2], Andrés Ortíz[3], Amanda S. Williard[4]

[1]JUSTSEA Foundation
[2]Ministerio de Ambiente Panama
[3]Autoridad Nacional de Acuicultura y Pesca
[4]University of North Carolina Wilmington

The East Pacific (EP) leatherback regional management unit is thought to have a very high risk for extinction, based on the dramatic 90% decline from 1980 in the number of nesting females at the major index nesting beaches; it is estimated that there are now fewer than 1000 adult female turtles in the EP. Unintended capture of adult and sub-adult EP leatherback turtles by fisheries operating while this species' foraging grounds are of particular concern, given the strong influence that these life stages have on population dynamics. There is a Regional Action Plan, which emphasizes the critical importance of

identifying areas of high bycatch risk, and specifically recommends the expansion of port-based marine turtle bycatch assessments to include Colombia and Panama. We conducted bycatch assessment surveys with artisanal and industrial fishers at major ports in Colombia (Tumaco, Buenaventura and Bahia Solano) and Panama (Puerto Vacamonte, Puerto Pedregal, and Puerto Mutis) to document interactions with and direct mortality of leatherback turtles in this region. Surveys were timed to coincide with peak fishing activity based on available government data. Survey results will be used to compare the nature and frequency of leatherback turtle interactions between fisheries operating in this region, and identify spatial and temporal patterns in fisheries interactions with leatherback turtles. Finally, the information generated in this study will be shared with broader, region-wide initiatives (LaudOPO, NFWF) to characterize bycatch of leatherback turtles in the fisheries of Central and South America and inform management decisions regarding conservation targets under threat reduction scenarios. Our research is the first of its kind in Colombia and Panama, and will lay the groundwork for additional studies and outreach activities.

CONSEQUENCES OF DRIFT AND DECAY OF SEA TURTLE CARCASSES FOR THE ESTIMATION OF TURTLE MORTALITY LOCATIONS FROM STRANDING DATA IN THE CHESAPEAKE BAY*

Bianca S. Santos[1], David M. Kaplan[1], Marjorie A.M. Friedrichs[1], Susan G. Barco[2], Katherine L. Mansfield[2,3], James P. Manning[4]

[1]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point VA, USA
[2]Virginia Aquarium & Marine Science Center, Virginia Beach VA, USA
[3]University of Central Florida, Orlando FL, USA
[4]National Oceanic Atmospheric Administration, Northeast Fisheries Science Center, Woods Hole MA, USA

Sea turtle strandings can provide important information on turtle mortality, but interpreting these events can be challenging. Forecast models can be used to predict the trajectory pathway of drifting objects at sea, including deceased sea turtles, but knowledge of the drift and decay characteristics of sea turtle carcasses is needed to better understand stranding data. The purpose of this study is to better parameterize sea turtle carcass drift, namely the probable oceanic drift times of turtle carcasses and the impacts of direct wind forcing on carcass drift. Carcass decay studies in the Chesapeake Bay, Virginia, USA were carried out to determine the buoyancy period of turtle carcasses and relate reported condition codes to probable water drift times. Drift duration of turtle carcasses from mortality at sea to beaching location was dependent on water temperature and occurred within 2-15 days under typical bay conditions from spring to early fall. The potential importance of direct wind forcing for turtle carcass drift was assessed by simultaneously deploying and tracking different types of surface drifters, including artificial buoys and actual turtle carcasses. Separation rates between turtle carcasses and near-surface artificial buoys not strongly impacted by winds were used to estimate the fraction of wind speed (i.e., leeway) that must be added to currents to accurately simulate carcass drift. Turtle drift along-wind leeway varied from 1-4 % of wind speed, representing a non-negligible change in carcass movement of 0.03-0.1 m/s. Together, these parameters were used to develop an oceanographic drift model predicting carcass trajectories after death to stranding locations in the Chesapeake Bay. To assess model validity, spatial overlap between probable origin of boat strike turtles and United States Coast Guard shipping lane data was assessed. Predicted mortality hotpots based on stranding locations during peak summer stranding periods were identified in waters of the lower Bay. Overall, the results from this study indicate that sea turtle drift time may be quite short and that direct wind forcing plays an important role in determining drift trajectories. These parameters are essential components in interpreting stranding data that should improve our ability to predict mortality locations from stranding events around the globe.

MAPPING THE GOODS: USING THE TURT SMARTPHONE APPLICATION TO RECORD HAWKSBILL PRODUCT USE*

Lidia Salinas[1,2], Stephen G. Dunbar[1,2]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc.), Loma Linda, CA 92350, USA
[2]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA 92350, USA

The historical and recent exploitation of hawksbill turtle shell (tortoiseshell) has been a driving force in the decline of hawksbill populations on a global scale. However, the hawksbill is by no means the only species that has been severely impacted by the anthropogenic use of turtle products. People around the world consume turtle meat and eggs on a regular basis, while tourists may request turtle products for consumption as a novelty, or unwittingly purchase turtle products as souvenirs. However, without a clear understanding of where turtle products are both sourced and marketed, turtle conservation efforts to inform government agencies, tourists, and tourism operators, will be hampered by lack of product-use locations and trends. Recently, ProTECTOR, Inc. released the Turtles Uniting Researchers and Tourists (TURT) smartphone application for recording in-water and nesting beach turtle sightings on a global scale. We decided to investigate the use of the TURT application for recording and mapping both locations and photographs of turtle products used in the country of Honduras. We used a standard oral survey in conjunction with the TURT smartphone app to collect information and map restaurants, souvenir shops, airports, open food markets, and hotels that use or sell either primary or secondary sea turtle products. We considered products that came directly to the vendor without pre-production to be primary products (eggs and meat), whereas products that underwent some form of pre-production prior to reaching the vendor were considered secondary products (jewelry, carvings). We also recorded sites that did not sell turtle products, allowing us to calculate a ratio of turtle product sellers to non-sellers for different types of vendors (hotels, restaurants, markets, souvenir shops). Additionally, we also collected information on the motivation of vendors for selling turtle products. We have surveyed 21 sites of potential turtle product sales in the cities of Tegucigalpa and Choluteca, Honduras, to date (surveys are continuing). Of these, 7 were souvenir shops, 5 open food markets, 5 restaurants, and 4 hotels. When survey data is combined for both cities, we found that 100% of souvenirs shops sold secondary turtle products, 100% of markets sold primary products, 60% of restaurants sold primary products, and 50% of hotels sold primary products. Motivations for selling primary products appear to be for sale to the tourism market, while sales of primary products appear to be motivated by traditional demand by local residents. The TURT app was a highly useful mobile tool for quickly collecting data and immediately mapping sites and product types. This study provides good evidence that mobile phone technology can be used to map trends in turtle product use at both local and national levels. Understanding where turtle products are used and sold will provide government agencies information on how to enforce national and international laws governing turtle exploitation, and increase awareness by tourists of their impacts on the use of turtle products. In the future, TURT may be used to map global trends in turtle products' uses and movements, in conflict with both national and international regulations.

IDENTIFYING LOCATIONS OF AND MECHANISMS FOR SEA TURTLE MORTALITY FROM STRANDING DATA USING OCEAN DRIFT MODELS

Bianca S. Santos[1], David M. Kaplan[1], Marjorie A.M. Friedrichs[1], Sarah A. Rose[1,2], Susan G. Barco[1,2]

[1]Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, VA, USA
[2]Virginia Aquarium & Marine Science Center, Virginia Beach, VA, USA

The Chesapeake Bay, Virginia, USA, and its surrounding coastal waters are significant foraging and developmental habitats for thousands of sea turtles, yet each summer, hundreds of turtles are found stranded on local beaches. As most sea turtle mortality likely goes unobserved due to low likelihood of landfall and carcass decomposition, these stranding events provide a unique window for studying drivers of turtle mortality. Nevertheless, the location and cause of these mortality events is largely unknown. We have developed an oceanographic drift model for the Chesapeake Bay simulating the drift patterns of turtle carcasses after death to stranding locations. Pseudo-particle drift trajectories were advected forward in time using an implementation of the Regional Ocean Modeling System for the Chesapeake Bay area as input to the offline Lagrangian drift simulation tool Ichthyop. The number of forward-tracked pseudo-particles arriving at stranding locations at the appropriate time were recorded for each stranding event as a basis for probabilistic maps of likely mortality locations based on the launch points of these trajectories. Our model incorporates empirical data on likely ocean drift duration before advanced decay causes the carcass to lose buoyancy, as well as estimates of the relative importance of winds and currents for turtle carcass drift. Buoyancy period was individually estimated for each trajectory based on ocean temperature data and field observations of carcass decay times, and varied between 1- and 10-days during spring/summer. The percentage of winds added to currents when modeling drift was varied from 0% to 4% and results were compared to assess the importance of winds for identifying mortality hotspots. This methodology allowed us to estimate probability maps for individual mortality maps, as well as averaged over many stranding events occurring over the time period 2001-2014. Simulations were focused on relatively fresh strandings occurring during the late-spring/ early-summer peak period.

THREATS TO OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) AT GODAVARI RIVERMOUTH NESTING HABITATS OF BAY OF BENGAL, INDIA

P. S. Raja Sekhar[1]

[1]Dept. of Environmental Sciences, Andhra University, Visakhapatnam-530 003, India

The Godavari river mouth (16o 17’ and 18o 30’ N longitude and 81o 30’ and 82o 37’ E latitude), is situated in East Godavari district of Andhra Pradesh, India. It is an important nesting habitat to Olive ridleys after Gahirmatha and Rushikulya beaches of Orissa Coast. The threats to Olive ridleys were classified into direct and indirect threats as described below: (i) Direct threats: Threats to breeding population, eggs and hatchlings and incidental catch in mechanized trawls / boats. (ii) Indirect threats: Loss related to marine, feeding habitats, nesting beaches (erosion, sand mining and beach armoring), Pollution from nearby Industries. Predation of nests and eggs on beaches: It was estimated by evaluating the factors i.e human excavated nests, eggs robbed by domestic and feral animals, nests spoiled due to wild animals, erosion of the beach sands, flood tides and other abiotic factors were considered together. For control of predation by feral and wild predators from beach erosion the following conservative measures were adapted: Conservation and Management, Onshore Conservation: Protection to Nesting Beaches: As the nesting

beaches are subjected to frequent erosion and tidal inundation, hence the following protection measures were implemented for the protection of the nesting beaches of Godavari river mouth. Control of beach Erosion: This type of erosion can be prevented through rehabilitation of native characteristic beach vegetation from foreshore to sand dune region consisting of the species, Casuarinas, Sand binders, Sea pinks, Screw pines, Horse shoe creepers, etc. Protection to Nests and Eggs: Predation on nesting beaches is more intensive during the nesting season from January to April. The vertebrate predators, jackals, foxes were frequently encountered at the nesting sites during the survey of the nesting beaches. To prevent the predation of eggs, nests and hatchlings, regular patrolling of the beaches during nights with the help of local fishermen community was organized. In-situ Conservation: As part of in-situ (natural) conservation, a total of six nests were protected and hatched under natural conditions, of which the mean hatching success obtained was 62 to 82 % with mean incubation time of 55 to 60 days (Table 5.17). Ex- situ Management: Freshly laid nests of Olive ridleys in low lying areas were relocated to the nearby suitable protected beaches for ex-situ management. Twelve nests were relocated to nearby protected beaches during the study period. The mean hatching success of these nests was between 52 and 58 % with a mean incubation period of 51 to 56 days. Whereas nests which are subject to heavy natural predation were protected with fence guards (2.5 x 1.5 ft) made of bamboo material and placed without disturbing the eggs or nests at a depth of 0.5 to 1 ft.

SPATIAL AND TEMPORAL ANALYSIS OF COASTAL CONSTRUCTION: IMPLICATIONS FOR MARINE TURTLE NESTING GROUNDS IN FLORIDA

Kristen Nelson Sella[1], Mariana M. P. B. Fuentes[1]

[1]*Florida State University*

Given concerns associated with coastal construction and its effects on marine turtles, many studies have investigated the effects of coastal construction on marine turtles and their habitat. However, these studies have often conducted assessments for specific and individual activities at one time and only for a few nesting grounds. Thus, limited information exists on the spatial and temporal trends and cumulative exposure of nesting grounds to coastal construction. This project examines coastal construction permits throughout the state of Florida as a proxy for the exposure and impacts of coastal construction to Florida's marine turtle nesting ground. Spatial data is available through the Florida Department of Environmental Protection (DEP) on coastal construction permits that have been issued along the sandy coastlines of Florida from 1980 through 2016. This data was categorized, verified, and analyzed to provide a historical summary of permitted activities (beach sand placement, beach armoring, sand fences, dredging, stormwater outfalls, channel and bridge blasting, beach cleaning, special events and light pollution), where the spatial and temporal variability of permits was explored. The temporal and spatial patterns of coastal construction throughout the state of Florida will be presented and the need for assessments of cumulative and synergetic activities will be discussed.

GLOBAL HARVEST AND TRADE OF MARINE TURTLES*

Jesse Senko[1], Maria del Mar Mancha Cisneros[1], Frances Humber[2], Lekelia D. Jenkins[1], Irene K. Kelly[4], Volker Koch[4], Andrew T. Smith[1], Trevor Fox[1], Casey Peterson[1], Annette C. Broderick[5,6], Brendan J. Godley[5,6], Bryan P. Wallace[7]

[1]Arizona State University, Tempe, AZ, USA
[2]Blue Ventures Conservation, London N7 9DP, UK
[3]Western Pacific Regional Fisheries Management Council, Honolulu, HI, USA
[4]CONANP, La Paz, BCS, Mexico
[5]Marine Turtle Research Group
[6]University of Exeter, Cornwall Campus, Penryn TR10 9EZ, UK
[7]Abt Associates Inc., Boulder, CO, USA

Marine turtles have been harvested for their meat, eggs, shell, skin, and other organs since at least 5000 BC. Today, despite national and international measures enacted to protect marine turtles, they are still consumed – legally and illegally – in coastal areas throughout the world. Here, we use the primary literature, media sources, and estimates from 46 in-country experts to assess annual global illegal take of marine turtles from 2000 to 2015. We discuss our take estimates in terms of number of turtles taken, species composition, and global distribution (i.e. countries and Regional Management Units). Our results suggest that current illegal take of green and hawksbill turtles is likely high despite dramatic decreases in large-scale commercial fisheries since the 1980s. However, illegal take appears to be biased towards regions where harvest has been assessed from the primary literature. Actual illegal take may be substantially higher in some areas where clandestine take has been documented, but where research is lacking, such as Southeast Asia. This potential discrepancy represents a challenge for managers, researchers, and communicators. Research is therefore needed to better understand and assess relative impacts of illegal take at both species and population-levels, as well as trade routes, supply chains, and market forces to help design economic deterrents and for strategic application of international enforcement efforts to mitigate illegal trade.

MEASURING PHYSIOLOGICAL RESPONSE IN SEA TURTLES FOLLOWING CAPTURE IN THE RECREATIONAL HOOK-AND-LINE FISHERY

Rachel Shoemaker[1], Susan G. Barco[1,2], Amanda S. Williard[1]

[1]UNC Wilmington, Dept. of Biology and Marine Biology, Wilmington, NC, USA
[2]Virginia Aquarium & Marine Science Center, Virginia Beach, VA, USA

Sea turtle interactions with commercial fisheries have been more widely studied in comparison to recreational fisheries. Bycatch in the recreational hook-and-line fishery has been listed as a potential threat to population recovery efforts, but there are currently no mandatory regulations in place to report or monitor sea turtle interactions for this fishery. The purpose of this study was to measure the physiological ramifications that the critically endangered Kemp's ridley sea turtle (*Lepidochelys kempii*) experiences following interactions with recreational fishing gear. Virginia Aquarium Stranding Response Program (VAQS) personnel obtained and provided blood samples for this study from a subset of Kemp's ridley turtles (n=8) landed by hook-and-line at recreational fishing piers from 2014 to 2015. All turtles were taken to the VAQS facility for further examination and another blood sample was obtained just prior to release. A repeated measures analysis was conducted to investigate the differences in blood biochemistry for

individual Kemp's ridley turtles at time of recreational hook-and-line capture and prior to release from the VAQS rehabilitation facility. Hematocrit, glucose, enzymes, ions, and blood gases were analyzed using individual turtles as their own control to determine if the turtles experienced physiological disturbances as a result of recreational hook-and-line capture. These data will be used to better characterize the impacts of interactions between turtles and recreational fisheries and to help provide guidance for best practices among recreational fishers to promote sea turtle recovery efforts.

IN-WATER STUDIES AND FISHERIES INTERACTION ON SEA TURTLES IN DALYAN, TURKEY

Doğan Sözbilen[1], Paolo Casale[2], Yakup Kaska[3]

[1]Pamukkale University, Department of Veterinary, Laborant & Veterinary Health Program, Denizli | Turkey
[2]Department of Biology, University of Pisa, Pisa, Italy
[3]Pamukkale University, Sea Turtle Research Centre (DEKAMER), Denizli, Turkey

Extensive monitoring studies on sea turtles have been carried out in the last 30 years in Turkey but all studies focused on nesting beaches only. There is a big lack of information about sea turtles in marine habitats. Limited satellite tracking studies showed that after nesting most nesting females migrate to North Africa coasts while other individuals were tracked to Turkey's coastline and Israel. No information is available about migration and distribution of males and juveniles. Stranding reports suggest that Turkey might have important foraging and wintering areas for the Mediterranean for all age classes and sexes. Most strandings from the winter season are caused by fisheries interaction. In this study, we aimed to assess the importance of the Dalyan marine area for sea turtles. Field studies were conducted from late February to April and 47 loggerhead turtles and 11 green turtles were captured during the studies. Turtles were captured by using a 600 m long net (meshsize 15 cm) and taken to the boat in 9 different sections in the area. Loggerhead turtles were caught in the sea and the lagoon behind the nesting beach. Green turtles were captured only in the sea and all green turtles were juvenile. Carapace length and weights of all captured turtles were measured and turtles were tagged before release. Body Mass Index for both species is provided. Physical examination was performed and any previous injuries and health conditions were recorded. Of these 47 loggerhead turtles, 25 were males, 13 were female and 9 were sub-adults. Three loggerhead turtles were recaptured in different sections. Of these females only one nested in the 2016 breeding season on Dalyan Beach. In physical examinations, old scars caused by boat propeller and fishing-line caused injuries were observed in 12 and five loggerhead turtles, respectively. During the summer, on-board studies to assess catch per fishing effort and interviews with fishermen were made. Fishermen are mainly fishing for shrimps with gillnet, where sea turtles are captured all year round. The second most used fishing method is longline targeting fish. During the study, no sea turtle was captured by nets but 3 turtles were found dead in the net in late summer. Moreover, 4 turtles washed ashore in September. Necropsy results and scars around the neck region indicate drowning in the net. Our results show that the Dalyan region has important wintering and foraging grounds beside its importance as a nesting area. Two sea turtle species from all age classes are living in the area and encountering problems with fisheries. Residential loggerhead turtle population size was estimated as 57±7,7 (95% CI= 50-86) individuals through a capture-mark-recapture model, while too few data on green turtles were available for this approach. These results are preliminary results for a relatively small region. Our observations and yearly stranding reports from other close rookeries suggest that Turkey hosts important wintering and foraging grounds for both loggerhead and green turtle populations. Further investigation is required to determine population size of sea turtles and main foraging areas to reduce mortality caused by fisheries interaction.

QUANTIFYING THE EFFECTS OF ROCK ARMORING ON SEA TURTLE NESTING SUCCESS IN NEW SMYRNA BEACH, FL

Amber Stevenson[1]

[1]*Ecological Associates Inc.*

Florida's sandy beaches have suffered increasing erosion over time, and the most recent assessment by the Florida Department of Environmental Protection (FDEP) designated 411.2 miles (49.8 percent) of beach as critically eroded (FDEP, Critical and Non-critical Erosion Areas Statewide. Updated August 2016). These beaches are important for many reasons including financial benefit to the state through tourism, protection of upland infrastructure through shoreline stabilization, and serving as nesting habitat for threatened and endangered sea turtles. Different methods of erosion prevention have been employed statewide, such as beach nourishment, dune restoration, and coastal armoring. A 13.5 km stretch of beach south of Ponce de Leon inlet in New Smyrna Beach, Volusia County, Florida, is considered critically eroded, and portions of this beach have been armored. Beaches managed by Volusia County host moderate nesting (~3-12 nests/km) by loggerhead sea turtles (*Caretta caretta*) and infrequent nesting by leatherback (*Dermochelys coriacea*) and green sea turtles (*Chelonia mydas*). However, loggerhead nest numbers have increased nearly three-fold since 1988. Nest data from 2006-2015 for loggerhead sea turtles were compiled and analyzed to quantify the effects of rock armoring structures on nesting success and reproductive success in New Smyrna Beach. Nesting success (the proportion of total crawls that result in nests) and reproductive success (hatching and emerging success) were compared among two adjacent, distinct shore types, rock revetment and natural dune, for a 1.01 km stretch of revetment shoreline and 1.55 km of natural dune shoreline. Nests deposited in front of rock revetments were subject to a higher average rate of relocation due to the imminent threat of tidal inundation or wash-out when compared to natural dune areas. Relocated nests were not included in analyses of reproductive success. Average nesting success over the ten-year period was 19.1 percent for the revetment area and 65.1 percent for the natural dune area. Statistical analysis of arc-sin transformed data revealed a significant difference (Mann Whitney $U = 0.0$, $n1 = n2 = 10$, $p < .001$). Average hatching and emerging success were lower in the revetment area (78.4 percent and 74.0 percent, respectively) compared to the natural dune area (84.0 percent and 81.0 percent, respectively). Arc-sin transformed data were grouped by treatment (Revetment vs. Natural Dune) and year to examine differences. A Kruskal-Wallis test showed a significant difference between treatment areas for hatching success ($H (1, N = 543) = 9.643$, $p < .01$) and emerging success ($H (1, N = 543) = 9.927$, $p < .01$). Comparisons by year did not reveal any meaningful information. These results suggest that the presence of rock armoring structures negatively affect the nesting behavior of loggerhead sea turtles when selecting nest sites and the reproductive success of nests incubating along these armored shorelines. As coastal conditions fluctuate with respect to climate change and sea level rise, it is critical that County coastal managers make decisions that meet the needs of coastal residents while considering impacts to sea turtles.

MITIGATING SEA TURTLE BYCATCH IN U.S. LONGLINE FISHERIES: ANALYSES OF 20+ YEARS OF OBSERVER DATA FROM THE PACIFIC AND ATLANTIC OCEANS*

Yonat Swimmer[1], Alexis Gutierrez[2], Keith Bigelow[1], Caren Barcelo[3], Barbara A. Schroeder[2], Kenneth Keene[4], Keith Shattenkirk[5], Daniel Foster[4]

[1]NOAA Fisheries Pacific Islands Fisheries Science Center
[2]NOAA Fisheries Office of Protected Resources
[3]Oregon State University
[4]NOAA Fisheries SEFSC
[5]Ocean Associates

Capture of sea turtles in longline fisheries has been implicated in population declines of both loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. United States (U.S.) pelagic commercial longline fisheries are managed to minimize capture and mortality of sea turtles. Since 2004, longline vessels targeting swordfish and tuna in the North Pacific and regions in the North Atlantic Ocean have operated under extensive fisheries regulations to protect endangered and threatened sea turtles. We analyzed more than 20 years of longline observer data from the Atlantic and Pacific from before (~1992–2001) and after the regulations (~ 2004–2015). Using generalized additive mixed models (GAMMs), we investigated relationships between the probability of turtle interactions and operational components such as fishing location, hook type, bait type, sea surface temperature, number of hooks per float, and use of light sticks. GAMM models were also used to quantify the probabilities of turtle captures in both regions as well as in the specific reporting areas within the Atlantic. Single factor analyses were conducted to evaluate the impacts of turtle bycatch as a function of regulations, such as changes in hook and bait type. Various analyses confirmed that in two U.S.-managed longline fisheries, catch probabilities of sea turtles has significantly declined as a result of fisheries regulations that mandated changes in longline fishing gear. For combined Atlantic observer data, nominal mean capture rates declined by 40% and 61% for leatherback and loggerhead turtles, respectively, for the period after the regulations. Within the NED area alone, where additional restrictions include a relatively larger circle hook (18/0) plus limitations on use of squid bait, sea turtle bycatch rates declined by 64% and 55% for leatherback and loggerhead turtles, respectively, for the period post-regulations. This management approach could be used within regional fisheries management organizations to reduce capture of sea turtles and promote sustainable fisheries on a global scale.

QUANTIFICATION AND IMPACTS OF NAUTICAL TRAFFIC ON HAWKSBILL PRESENCE IN A HONDURAN MARINE PROTECTED AREA: A PROGRESS REPORT

Marsha K. Wright[1,2], Dustin S. Baumbach[1,2], Daniel Trujillo[3], Justin Cruz LeDuc[4], Lidia Salinas[4], Stephen G. Dunbar[1,2,4,5]

[1]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA 92350, USA
[2]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc.), Loma Linda, CA 92350, USA
[3]Department of Biological Sciences, Walla Walla University, College Place, WA 99324, USA
[4]ProTECTOR Inc. Internship Program, Loma Linda, CA 92350, USA
[5]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR - Honduras) Tegucigalpa, Honduras

Marine protected areas (MPAs) have been implemented to help reduce negative impacts of human activities on marine organisms. However, many MPAs overlook specific threats, such as nautical traffic. Boat presence has been shown to alter typical activity patterns, increase stress, and lead to physical injury in marine animals. The Sandy Bay West End Marine Reserve (SBWEMR) was implemented to protect the northwestern shore and marine environments of Roatán, Honduras, and the organisms that inhabit them, including the hawksbill sea turtle. However, there are many dive centers, hotels, and marinas in the SBWEMR, all of which generate boat traffic. To evaluate the variation in boat traffic, and its relation to hawksbill presence throughout the SBWEMR, we divided the reserve into 3 zones: West Bay (WB), West End (WE), and Sandy Bay (SB). We further divided these zones into sectors for counting purposes. The WB, WE, and SB zones were comprised of 4, 5, and 5 sectors, respectively. Boat counts took place over a period of 70 days, with observations in each sector lasting 20 minutes within three time periods: morning (8:30-10:30), midday (12:00-14:00), and late afternoon (14:30- 16:30). Boat counts in each time period were used to calculate boat intensity (i.e. the number of boats passing through an area per hour). A total of 2,957 boats were counted. Our data did not show a difference in boat intensity between the WB and WE zones. However, boat intensity in the SB zone was significantly lower than both the WB and WE zones. We also found no difference between the morning (WB = 44, WE = 44, SB = 11), midday (WB = 36, WE = 37, SB = 5), or late afternoon (WB = 38, WE = 43, SB = 9) time periods. A total of 93 in-water hawksbill surveys were completed using SCUBA in the WB and WE zones in the morning (WB = 30, WE = 14) and late afternoon (WB = 18, WE= 31). During the surveys, hawksbill sightings were recorded in WB and WE in the morning (WB= 22, WE=12) and late afternoon (WB= 15, WE= 24). Sightings were normalized to account for unequal observations, with no differences in hawksbill sightings observed between zones or time periods. These preliminary results suggest there is no difference in hawksbill presence in the WB and WE zones. However, more data collection is needed from the SB zone to complete the analysis of turtle presence throughout the SBWEMR. Preliminary in-water observations of hawksbills in the presence of boats suggest that they are indifferent to boat traffic. However, other factors, such as maturity and near-encounters with boats, could affect their responses. Further studies of juvenile hawksbills in the presence of boats will help clarify the impacts of boat traffic on hawksbill behavior and their resulting distribution throughout the reserve. Data collected from this study can be used to determine the adequacy of the marine reserve and if boat traffic should be monitored and regulated.

EVALUATION OF SEA TURTLES BY-CATCH DURING SHARK FISHING IN THE CENTRAL NORTH OF SINALOA

Alan A. Zavala-Norzagaray[1,2], César Paúl Ley-Quiñonez[1,2], Catherine E. Hart[2], Renato Leal-Moreno[1,2], Brenda Aracely Espinoza-Romo[1], Alexis Antonio López-García[2], Carlos Gregorio Romero-Urías[2], Sandoval-Lugo Alejandra Guadalupe[1], Maria del Rosario Vejar-Rubio[1], Kevin Alan Zavala-Félix[3], A. Alonso Aguirre[4]

[1]Instituto Politécnico Nacional CIIDIR- SINALOA
[2]Grupo Tortuguero de las Californias A.C.
[3]Universidad de Occidente Campus Guasave
[4]Department of Environmental Science and Policy George Mason University

The central-northern part of the state of Sinaloa, Mexico, is considered an important feeding area for five species of sea turtles. However, there is evidence of incidental capture of sea turtles in gill nets aiming shark fishing, although the magnitude and the relationship of this activity to the mortality and sea turtle stranding in the area is unknown. The aim of this study was to characterize the shark fishing activity and the incidental capture of sea turtles by these fishing gears. This project was achieved through the participation of fishermen from the Reforma community, Sinaloa, Mexico, which has a fleet of approximately 25 boats. The bycatch of 87 sea turtles in shark fishing nets, 38 Lepidochelys olivacea, 26 Chelonia mydas agassizii, 20 *Caretta caretta* and three *Dermochelys coriacea* was recorded from 2012-2015. All turtles that were captured, according to their sizes, correspond to subadult stages. The overall CPUE observed in the project was 1.8 / 12hrs. In northwestern Mexico, particularly in the Gulf of California, few studies have reported CPUE for sea turtles. In the literature search we found it was reported only for the species *C. caretta* in Bahia Los Angeles (Seminoff et al., 2004). The authors report a total of 15 loggerhead turtles over a six-year period, with a CPUE of 0.007 / 12hrs, and suggest that the Gulf of California may not represent a significant habitat for the *C. caretta* turtle in the eastern Pacific. This differs with this study's result where the CPUE obtained from the captured loggerhead turtles in the study area was 1.8 / 12hrs, and the participating fishermen reported seeing approximately 100 loggerhead turtles during the three year monitoring. According to the CPUE obtained, there was a sea turtle bycatch of around two turtles every 12 hours in the shark fishing nets by boat, only in the community of the Reforma, Sinaloa, Mexico. On the other hand, the corresponding Mexican governmental institutions do not have current information on the size of the fishing fleet dedicated to this activity, so it’s not possible to estimate the impact of sea turtle bycatch by shark fishing in Mexico. The present study provides a platform for new studies that contribute to the knowledge of these populations, and allows better integrated management of marine turtle protection programs in the region, and particularly in Sinaloa.

SEA TURTLE STRANDINGS ALONG GULF OF CALIFORNIA ISLANDS BEACHES: FURTHER EVIDENCE OF FISHERIES IMPACT IN NORTHERN SINALOA, MEXICO

Kevin Alan Zavala-Félix[1,2], César Paúl Ley-Quiñonez[3,2], Catherine E. Hart[4,2], Renato Leal-Moreno[4,3], Brenda Aracely Espinoza-Romo[2,3], Alexis Antonio López-García[2], Carlos Gregorio Romero-Urías[2], Sandoval-Lugo Alejandra Guadalupe[2,3], Maria del Rosario Vejar-Rubio[2,3], A. Alonso Aguirre[2,5], Alan A. Zavala-Norzagaray[2,3,4]

[1]Universidad de Occidente Campus Guasave.
[2]Grupo Tortuguero de las Californias A.C.
[3]Instituto Politécnico Nacional, CIIDIR- SINALOA
[4]ICSAS A.C.
[5]Department of Environmental Science and Policy | George Mason University

From June to December 2014, 73 beach surveys were carried out to register sea turtle strandings on the islands of Altamura, Macapule, San Ignacio and Santa Maria, Sinaloa, Mexico. The aim of this study was to identify the strandings associated with an anthropogenic impact. 165 cases of sea turtle strandings were documented, mainly in the months from June to August (136 cases), in most of these cases it wasn´t possible to determine the cause of death due to the high grade of decomposition of the organisms. During and prior to the dates of the stranding records, in the marine-coastal part of the study area, there is an important and little regulated fishing activity targeting several species of fish, both by small-scale fisheries and by industrial boats, during which there exists bycatch of different species, including sea turtles, which could be causing the drowning of these sea turtles. Considering the time that a dead turtle takes to reach the coast due to wind and currents and other factors that affect the decomposition of organisms and based on the consulted literature, it has been estimated in other places that the stranding of the organisms represents less than 20% of the actual mortality, so we can assume that the approximate mortality is of 825 turtles in the study area, without considering the turtles that are taken by the fishermen for illegal exploitation and consumption.

In-Water Biology

MOVEMENTS OF GREEN TURTLE (*CHELONIA MYDAS*) IN THE NATURAL NATIONAL PARK ISLA GORGONA, COLOMBIAN PACIFIC

Diego Amorocho[1]

[1]*WWF-Colombia*

In order to advance towards the conservation of species and to understand the role of space-time movements within protected areas, we tracked movements of 10 green turtles in the Colombian Pacific within the protected area of the Isla Natural National Park Gorgon. Satellite transmitters were used for periods of 17 to 161 days between 2009 and 2011 (mean ± SD: 47.9 ± 47.2 d) Length range of the curved carapace of the turtles is between 52.4 and 72.8 cm (64.4 ± 6.9 cm). Nine of the 10 turtles were resident in the coastal waters of the island, only one of them showed a pattern of migration towards south of continent, near the coast of Ecuador. A large percentage of the locations are within the borders from protected marine area (87%). Average distribution range was calculated for two parameters, for 90% was 76.89 ± 71.38 km2 and for 50% was 15.31 ± 16.87 km2, none of these values correlated with the size of the turtle nor with the number of days transmitted. The mean velocity was 18.23 (DE: ± 4.37 km / d) and there were no significant differences (F (9, 468) = 0.39371, p = 0.93812). However, average distance traveled between points of location (7.97 ± 7.32 km) presented significant differences (F (9, 468) = 10,964, p = 0.00000), the most marked case was turtle called Isabel, which presented differences with the rest of the population. This difference could be explained by the nature of the movements presented by this individual, because it was the only who begings migratory movement toward south. This study allowed to identify and characterize movements of individuals of the green turtle in the Gorgona Island Natural National Park, which highlights the value of telemetry studies for the conservation of species and the management of protected areas, because it determined temporary residence during the juvenile and sub-adult status of the green turtle within the protected marine area.

POST-NESTING MIGRATION OF LOGGERHEAD TURTLES NESTING AT THE SOUTHERN PART OF JAPAN

Mamiko Arita[1], Junichi Okuyama[1], Kaede Tomidokoro[1], Yasushi Mitsunaga[1]

[1]*Research Center for Subtropical Fisheries Seikai National Fisheries Research Institute, Fishery Department, Faculty of Agriculture, Kindai University, Japan.*

Post-nesting migration of loggerhead turtles nesting in Japan was investigated well using satellite tracking. Hatase et al. (2002) first revealed that loggerheads exhibit a size-related migration (foraging) dichotomy after nesting; smaller females migrate to oceanic area in the north Pacific, whereas larger females to the neritic waters in the East China Sea. However, these migration studies were conducted only in the northern and middle regions of nesting places in Japan (e.g. Yakushima, Minabe). In this study, post-nesting migration of four loggerhead turtles nesting on Okinoerabu Island which located on the southern part of Japan was investigated by using a satellite relay data logger (SMRU instrumentation). Four females were tracked for 59 and >153 days (still tracked). The largest female (91.5 cm in straight carapace length (SCL)) migrated into the neritic East China Sea after the nesting season, and stayed there with wider home range (27,162 km2 in the minimum convex polygon (MCP)). The 2nd largest female (86.0 cm in SCL) moved

into the coastal area of the mainland of Japan with narrow home range (660 km2 in the MCP). Meanwhile, the other smaller females (78.5 cm and 79.8 cm in SCL) migrated on the way of Kuroshio Current and Kuroshio Extension Current, and then to oceanic area in the North Pacific. After entering oceanic region (around 150° E to 165° E), their trajectories sometimes showed clockwise/ counterclockwise rotations, presumably indicating they were transported by eddy. These results indicate the size related migration dichotomy also appeared for the females nesting on the beaches in the southern part of Japan.

WHAT'S A NICE GUY LIKE YOU DOING IN A PLACE LIKE THIS? SATELLITE-TRACKING MALE GREEN TURTLES AT THE ARCHIE CARR NATIONAL WILDLIFE REFUGE, THROUGHOUT THEIR MIGRATION, AND AT THEIR FORAGING GROUNDS*

D.A. Bagley[1], Alexander E. Sacco[1], L.M. Ehrhart[1], Katherine L. Mansfield[1]

[1]Dept. of Biology, University of Central Florida, Orlando, USA

Male green turtles were encountered and outfitted with GPS-enabled satellite transmitters within the Archie Carr NWR in east central Florida, USA, prior to or at the outset of the nesting season. Males ranged in size from 90.7-101.1 cm scl (n=9, mean 93.7). Days spent in "mating mode" averaged 33 days (n=9; range 10-49 days) before departing. It is evident from tracking data that much of their time at night was spent immediately off the shoreline. We examined breeding areas used by these males and observed several patterns in their behavior, so that making generalizations remains difficult. Some males spent all of their time off the beach near the deployment location before returning directly to foraging areas (n=4). Other males made movements north and/or south, but returned to near the deployment location before making their migration to foraging areas (n=3). Two males left the Refuge within a very few days and spent time off other nesting beaches on the way to their foraging grounds. Eight of nine turtles returned to different locations in the Florida Keys before one continued on to the Yucatan. One turtle migrated to forage just 43 km south of the Carr Refuge nesting beach. Migration time from the Carr Refuge to foraging destinations averaged 14 days (range 1-20) but the first foraging area was not necessarily the final destination. Total distance traveled by each turtle averaged 1,183 km (n=9; range 256-2,387 km). We conducted kernel home range density analysis on locations off the nesting beach and at foraging grounds.

OCEAN PATHWAYS AND RESIDENTIAL FORAGING LOCATIONS FOR SATELLITE-TRACKED GREEN TURTLES BREEDING AT FRENCH FRIGATE SHOALS IN THE HAWAIIAN ISLANDS

George H. Balazs[1], Denise M. Parker[2], Marc R. Rice[3]

[1]IUCN/SSC Marine Turtle Specialist Group Oceania Region, Honolulu, Hawaii, USA
[2]IUCN/SSC Marine Turtle Specialist Group Oceania Region, Philomath, Oregon USA, Hawaii, USA
[3]Preparatory Academy, Kamuela, Hawaii, USA

From 1992-2014 the breeding migrations of 20 green turtles, *Chelonia mydas*, were satellite tracked either from or to the geologically ancient colonial nesting site of French Frigate Shoals (FFS) mid-point in the 2400 km arc of Hawaiian Islands. Using the Argos System, ocean routes and travel schedules were mapped and the home ranges of foraging area destinations were calculated and portrayed by Minimum Convex Polygons. None of the turtles migrated outside the Central North Pacific (CNP) region of Hawai'i, consistent with prior long-term results of comprehensive flipper tagging and genetics research. Fifteen of

the 17 turtles tracked from FFS migrated to the Main Hawaiian Islands (MHI) to the southeast, while one turtle went directly south to the foraging site of Johnston Atoll within the CNP, and another ceased transmitting midway between FFS and the MHI. Transit times from FFS to the MHI ranged from 16-94 days; the turtle that traveled to Johnston also took 16 days. Distances covered during each migration ranged from 830-3936 km with travel rates of 1.2-2.5 km/hr. Upon arrival at residential locations transmissions continued for 2-314 days. The post-breeding pathways taken by the turtles to the MHI from FFS comprised two general corridors. Thirteen of the turtles moved southeast of the island chain staying over deep oceanic waters until arriving in the MHI. In contrast, two turtles traveled a more direct pathway over the banks and reefs of the Hawaiian chain to reach the MHI. In both cases once the turtles arrived in the MHI they traveled coastally until crossing the deep channels separating each of the MHI. However, inconsistent with all others, one turtle traveled 3936 km over a 94-day period on the high seas in a huge circular route before arriving at the Island of Kaua'i in the MHI. Three turtles tracked to FFS from a MHI foraging site on O'ahu swam from 10-200 km to the west past FFS before reversing course to arrive at the FFS breeding destination. Nine widely separated home range foraging destinations for the migrant breeding turtles were identified. Two of the largest bays in the Hawaiian Islands- Kane'ohe Bay on O'ahu and Kahului Bay on Maui- were the destinations for ~60% of the turtles, thereby emphasizing the conservation importance of these two locations for adults in the Hawaiian green turtle population. Our study brings together for the first time tracking data collected over the span of 22 years. Novel and as yet unanswered aspects of our results point the way for future telemetry with this globally isolated genetically discrete green turtle population that has shown significant improvements in conservation status over the past 45 years of intense investigation (see http://www.iucnredlist.org/16285718/0).

PISCIVORY BY LOGGERHEADS IN VIRGINIA, USA

Susan G. Barco[1], Erin E. Seney[2], Ashley L. Bunch[3], Kristy M. Phillips[1], Shannon J. Reinheimer[1], Sarah A. Rose[1], Amanda S. Williard[2]

[1]*Virginia Aquarium*
[2]*UNC Wilmington*
[3]*University of Central Florida*

Loggerhead turtles (*Caretta caretta*) occur seasonally in Virginia and primarily strand from May-November. During 2009-2015, 1,036 non-hatchling, dead loggerhead strandings were reported. Of these, gastrointestinal tract (GI) contents were examined from 372 turtles (36%) that measured 50.5-115.1cm straight carapace length (SCL; mean±SD=73.7±14cm). Percent of GIs containing fish ranged from 21%-57% annually (35% overall). In an earlier study of Virginia loggerhead diet over three time periods, Seney and Musick (2007) found fish in GIs similar to this study from 1983-1992 but reported that ~60% of GIs from 1993-2002 contained fish, nearly double the earlier time period. The SCL of loggerheads that had consumed fish (n=133; 68.3±8.6cm) was significantly less than SCL for those that had not (n=239; 78.4±15.6cm) (Wilcoxen rank sum W=21,713, $p<0.0001$). When separated into 15cm SCL bins, fish presence was significantly affected by bin (KW X2=50.457, $p<0.0001$) with 56-70cm and 71-85cm bins more likely to have fish than 86-100cm (56-70 $p<0.0001$; 71-85 $p=0.0005$) or 101-115cm (56-70 $p=0.0017$; 71-85 $p=0.008$). No fish were found in the GIs of turtles >95cm SCL (n=41), similar to Seney and Musick (2007). Occurrence of fish was also significantly affected by season (KW X2=38.968, df=2, $p<0.0001$). Summer (July-Sep) and fall (Oct-Dec) had a smaller ratio of examined GIs containing fish than spring (Apr-Jun). Fish were more common in turtles that stranded within Chesapeake Bay than those from Atlantic Ocean coasts (W=20,033, $p<0.0001$). The overall F:M sex ratio of stranded loggerheads was 63%:37%, and sex ratios of loggerheads with and without fish were nearly identical. Index of relative prey importance (IRI) and %IRI were calculated for 71 whole loggerhead GIs from 2010-2012. The five most important

prey groups overall, based upon %IRI, were horseshoe crabs (*Limulus polyphemus*), Busycon whelks, blue crabs (*Callinectes sapidus*), bony fishes and hermit crabs (*Pagurus* spp.; Seney et al. 2014). When separated into GIs with (n=22) and without fish (n=49), the highest %IRI prey were bony fishes, horseshoe, spider (*Libinia* spp.), blue and hermit crabs for the first group and horseshoe crab, whelk, blue, spider and hermit crabs for the second group. The %IRI for fishes in the fish-eating group was 78.6% whereas the combined %IRI of the next four highest prey was just 8.2%. Percent-IRI values ranged from 3.0-40.3%% for the top five prey in the non-fish-eating group. Loggerheads that stranded in Virginia with fish in their GIs were smaller, more likely to strand in spring, and less likely to consume traditional invertebrate prey compared with conspecifics that had no fish in the GI. The question arises whether piscivore loggerhead turtles are resource limited, and, thus, have turned to feeding on non-traditional prey or whether they have abandoned traditional prey for relatively calorie-rich and easily-available fishes. Feeding primarily on fishes may put smaller (56-70cm) loggerheads at greater risk for interacting with fishing gear, and, in Virginia, these smaller size classes represent 75% of the documented mortality. The association between piscivory and higher mortality in the smaller size classes warrants additional research.

THE DEVELOPMENT OF LOCAL AND GLOBAL CITIZEN-SCIENCE SEA TURTLE MONITORING

Dustin S. Baumbach[1,2], Edward Anger[3], Stephen G. Dunbar[1,2,4]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc.), Loma Linda, CA 92350, USA
[2]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA 92350, USA
[3]ScubaTed, Roatán, Honduras
[4]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc. – Honduras), Tegucigalpa, Honduras

Geographic Information Systems (GIS) are changing how ecosystems and individual species are monitored by providing ease of access to wide-scale spatial views. With recent developments in web-based GIS, citizen-scientists are now able to participate with researchers in scientific studies by providing data points of their own observations. Recently, we developed and launched two interactive maps with nine editable fields for logging in-water turtle sightings around the islands of Roatán and Utila, located in the Bay Islands of Honduras. Ninety-eight dive site locations for the island of Roatán and 74 dive site locations for the island of Utila were mapped with lat/long positions on Esri's ArcGIS Online web map. We embedded these maps on the website for the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR, Inc.) and distributed it to dive shops on Roatán for use in logging turtle in-water sightings, and uploading photographs and metadata. Dive shops on Utila have not yet been provided with the sightings link because we have not returned to that island since the maps were launched. To date, 105 sea turtle sightings have been logged for the Roatán map. However, we recognized that dive tourists do not always have immediate access to a computer to log sea turtle sightings. In order to facilitate the collection of important information, smartphone applications designed to map wildlife sightings are used for citizen-scientists to aid researchers in collecting scientific data. Many smartphone applications are currently available for Androids and iPhones that help log animal information worldwide utilizing GPS positions from the user's phone. We recently designed a smartphone application called Turtles Uniting Researchers and Tourists (TURT) for logging global citizen-science sea turtle sightings. We utilized Esri's AppStudio native quick report template to specify the basic identifying application information, insert the feature class, and create custom code to provide instructions for logging information. The feature class was then linked to our interactive web map in order to facilitate the ease of logging sightings on Roatán without having to

use a computer. We limited identifying information provided to the user to prevent poachers from taking advantage of GPS locations for turtle sightings. After TURT was released to the Google Play and Apple App stores, we announced the release of the application to the C-Turtle e-mail list and to dive shops in the Caribbean and southeast Asia. Currently, 146 separate turtle sightings consisting of 39 Greens, two Leatherbacks, 102 Hawksbills, two Loggerheads and one undetermined turtle have been logged for the United Kingdom, U.S. Virgin Islands, Honduras, Guam, and in the United States, Florida, Hawaii, and Texas. We suggest that dive guests should be engaged directly to inspire self-motivation to act as citizen-scientists. However, we have found it challenging to engage the public and other researchers to use these applications, and are currently considering the use of incentives. These data may allow marine protected area managers to easily estimate and monitor sea turtle populations with the combined use of TURT and region-specific web maps.

EFFECT OF BURROWING SEA CUCUMBERS, *HOLOTHURIA ARENICOLA*, ON GREEN SEA TURTLE FORAGING IN SEAGRASS BEDS OF ABACO, BAHAMAS

Liberty Boyd[1,2], Elizabeth R. Whitman[1,3], Dr. Elizabeth Stoner[4], Dr. Stephanie Archer[5], Pamela Murata[3], Micheal Heithaus[3], Katherine Comer-Santos[3]

[1]*The Science Exchange*
[2]*Florida Atlantic University*
[3]*Florida International University*
[4]*Loxahatchee River District*
[5]*Department of Fisheries and Oceans Canada*

Thalassia testudinum seagrass beds provide critical foraging habitats and the primary food source for a variety of species in the Caribbean, including juvenile green sea turtles. *Holothuria arenicola* can serve as an ecosystem engineer, influencing community and environmental dynamics of these seagrass beds by physically altering the benthic make up while also adding nutrients through bioirrigation. Currently, *H. arenicola* is listed as data deficient by the International Union for Conservation of Nature, and the overexploitation of other species of sea cucumbers by fisheries exists in the Caribbean, posing potential indirect threats to green sea turtle foraging habitat. Other studies have shown that the spatial variation and nutrient content within seagrass beds influence juvenile green turtle foraging. We suspect that *H. arenicola* could be influencing nutrient levels and spatial variance in oligotrophic *T. testudinum* beds, revealing an unexpected potential indirect interaction between burrowing sea cucumbers and green sea turtles. To assess the ecological role of *H. arenicola* in seagrass beds and their influence on green sea turtle foraging, we evaluated their ability to physically alter the benthos though mound building and identified the effects of mound proximity on nutrient content of seagrass and algae from June through August of 2016, at two distinct research sites in Abaco, Bahamas. We also monitored mound turnover rates within six 15 m2 study plots at each of two distinct research sites, conducted seagrass community and abundance surveys, captured GoPro® video of displaced individuals that were excavated from their mounds to observe their burrowing and locomotive behaviors, and collected seagrass and fecal samples from 12 active mounds for nutrient content analysis. We also included data from two-years (5 sampling events from 2014 to 2016) of data on seagrass nutrient content, seagrass community composition and abundance, and evidence of green turtle grazing. Over this two-year period, we also observed a shift in the seagrass community from *Thalassia testudinum* dominated beds to *Halodule wrightii* at one study site. Community shifts can be caused by the addition of nutrients, so it is imperative that we understand the role of *H. arenicola* in the nutrient cycling. Preliminary results indicate a positive correlation between the density of *T. testudinum* and the number of active *H. arenicola* mounds. Our results further point towards an indirect facilitative relationship between

burrowing sea cucumbers and green sea turtles, and provide support for additional research and conservation measures to protect *H. arenicola* from over-exploitation.

PALATABILITY OF SEAGRASS SPECIES IN BREWERS BAY, ST. THOMAS, USVI

John S. Cassell[1], Paul Jobsis[1], Edwin Cruz-Rivera[1], Sandy Wyllie-Echeverria[1]

[1]*University of the Virgin Islands, USA.*

Green sea turtles, *Chelonia mydas*, feed on multiple seagrass species in the U.S. Virgin Islands. However, a recent invasion by the seagrass, *Halophila stipulacea*, to the Caribbean has caused concern regarding its impact on herbivores. This plant is found in multiple bays on St. Thomas where *C. mydas* forage, yet few observations of this species consuming it have been documented. Furthermore, since its introduction to the Caribbean there has been no information published on the nutrient content of H. stipulacea, which is necessary to determine how herbivores will perceive it as a food source. This project is the first to examine the nutritional quality and palatability of seagrasses found in Brewers Bay through chemical analyses, observational surveys, and choice-feeding experimentation. We collected *H. stipulacea* and two native seagrasses, *Thalassia testudinum* and *Syringodium filiforme*, between 2016 and 2017 to compare nutrient contents seasonally. In addition, weekly snorkel surveys through the bay were conducted to count the number of turtles present and whether they grazed within monotypic or mixed beds of invasive and native plants. A pilot behavioral study was designed to follow individual turtles for 30 minutes and record how long they spend foraging, diving, surfacing, or resting. To determine feeding preferences with other species we used a mesocosm to offer the longspine sea urchin, *Diadema antillarum*, each seagrass simultaneously for two days. Seagrass samples were shipped to collaborative laboratories in the United States for analysis on their carbon, nitrogen, protein, carbohydrate, lipid, mineral, acid detergent fiber, and phenolic compound contents. For sea turtle surveys an unperturbed behavior towards *H. stipulacea* was observed. While a one-way analysis of variance revealed a significance (p<0.001) in where turtles were spotted feeding, 43% of the total counted were in mixed patches containing the invasive seagrass. Furthermore, an unpaired t-test of averaged time individual turtles foraged during 30 minute surveys showed turtles feasted within mixed patches significantly (p<0.001) more than monotypic native ones. However, when offered three seagrass species in a mesocosm, a non-parametric Friedman's Test showed *D. antillarum* had significant (p=0.008) preference to S. filiforme. However, it is important to note that some test subjects ate the invasive plant instead of the native ones offered. Overall, the results of this project are crucial for researchers and natural resource managers examining the impacts of *H. stipulacea* within the Caribbean. These sea turtle and urchin feeding patterns suggest other herbivores may have a likeness to eating *H. stipulacea*, which will affect how ecologists will portray it in our marine ecosystems as it expands beyond its original territory.

INVESTIGATING THE MIGRATORY ECOLOGY OF FLORIDA LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) USING STABLE ISOTOPES

Ryan M. Chabot[1], Jacob R. Kelley[1], Christopher A. Long[1], Alexander E. Sacco[1], Erin E. Seney[1], Gustavo D. Stahelin[1], Katherine L. Mansfield[1]

[1]*University of Central Florida, Orlando, FL, USA*

Leatherback sea turtle (*Dermochelys coriacea*) annual nest numbers in Florida, USA, have grown at an annual rate of approximately 10.2%, with a trend of 15.0% for South Brevard County. These increases are

encouraging indicators for population recovery, but their drivers are poorly known. Changes in food web dynamics have been postulated as one such driver. Where nesting females choose to forage during non-breeding intervals can have direct ramifications on their survival and reproduction in subsequent seasons. The 21-km Brevard County portion of the Archie Carr National Wildlife Refuge (ACNWR) on the east coast of Florida has been identified as one of the northernmost nesting beaches within the geographic area of peak percent increase in leatherback nesting. A previous satellite tracking study of ACNWR nesting leatherbacks indicated putative foraging areas located in continental shelf waters offshore of the northeastern United States, pelagic waters of the North Atlantic, and off the coast of West Africa. However, these only represent a snapshot of this population's post-nesting destinations. Identifying the number of foraging areas, and their relative contribution to the nesting population, is an important step toward understanding how non-breeding habitat may be influencing population recovery. Stable isotope analysis of sampled tissue has been used successfully in several marine turtle studies to delineate distinct foraging aggregations of females from the same nesting beach. We assigned a subset of leatherbacks using skin samples collected on the ACNWR from 2002-2016 (n = 56, mean curved carapace length = 150.3 cm +/- 7.2 SD) to putative foraging aggregations using δ13C and δ15N values in a Gaussian finite mixture model clustering approach. Eighteen additional samples collected from 14 of these 56 individuals in different years were analyzed to examine consistency in isotopic signatures between nesting seasons using generalized linear models. We compared isotope data from ACNWR nesters with published values from both Atlantic nesting and foraging leatherback populations. This allows for strong inference as it relates to identifying the number (and possibly location) of foraging areas for this rookery. We also used these putative foraging assignments to test for differences in reproductive output (clutch size: 75 eggs +/- 18 SD) between these areas after accounting for body size. This information will aid in the prioritization and protection of leatherback foraging habitat and further our understanding of potential habitat influences on fitness.

GREEN TURTLE POPULATION AT TROPICAL FJORD DULCE GULF IN COSTA RICA

Didiher Chacón[1]

[1]*LAST*

Catch per unit effort and population structure of the Pacific green turtle (*Chelonia mydas*) in the Golfo Dulce, Costa Rica. The Golfo Dulce is one of the few tropical fjords in the world, and has recently been declared a Marine Area for Responsible Fisheries (AMPR), harboring mangrove ecosystems, coral reefs and seagrass beds, which are important feeding areas for green turtles (*Chelonia mydas*). In this study we estimate the catch per unit effort (CPUE) and population structure in a site in the western sector of the Golfo Dulce. Between August 2010 and August 2016, were captured a total of 805 green turtles (including 273 recaptures) using entanglement nets. The annual CPUE (CPUE, 1 unit: 100 m of net for 7h) during the study ranged between 0.19 and 0.45, decreasing gradually over the years, possibly prompted by mass mortality occurred in January 2013. We found that seasonality and temporality influence the CPUE according to the best-fit model. About 81.37% were considered adult females, with an average length of curved carapace (LCC) of 79.4±0.9cm. The female recaptured has been tagged previously in the Galapagos Archipelago. While none of the turtles tagged in the Golfo Dulce was reported nesting on any other beach. Our results suggest that the Golfo Dulce is an important area for green turtles, where individuals congregate for adults and subadults would feed on seagrasses and the fleshy parts of the mangroves. The area also represents a major challenge for international conservation, possibly because we captured adult females from nesting beaches of Panama and Colombia, which requires multilateral agreements that promote the recovery of the East Pacific green turtle. We suggest the continuation of this conservation project to use sea turtles as umbrella species to protect ecosystems in the Golfo Dulce.

HOW THE THREE-DIMENSIONAL OCEAN ENVIRONMENT INFLUENCE THE MARINE TURTLE DIVING BEHAVIORS*

Wan-Hwa Cheng[1], I-Jiunn Cheng[2], Elija Flores[1], Ahmed Alhayki[1], Xi Yang[1], Byounghoon Kang[1], Trisalyn Nelson[1]

[1]Arizona State University, [2]National Taiwan Ocean University

Sea turtle movement is three-dimensional, as diving is integral to movement processes. Most sea turtle movement studies only consider two-dimensions. Our goal is to address a critical gap in our understanding of how sea turtles move through ocean habitats by modeling the relationship between three-dimensional sea turtle movement and three-dimensional ocean conditions. The study is conducted in and uses 1594 movement segments from 2011 to 2012, and 2015 of green turtle (*Chelonia Mydas*) movement during the internesting period. The link between movement and environmental parameters (including sea surface and ocean temperature, bathymetry, chlorophyll-a concentration, and oceanography features such as ocean current) was evaluated using statistical models. Results indicate in three areas, the coast region, deep water and shelf region, where environmental parameters had a stronger influence on diving behaviors. This study also indicates how environmental parameters influence different diving styles. Understanding how sea turtles utilize three-dimensional habitats will also provide better management for green turtles.

COMPARING THE INTER-NESTING BEHAVIOR OF GREEN TURTLES FROM TWO NEIGHBORING BEACHES IN PACIFIC COSTA RICA

Chelsea Clyde-Brockway[1,2], Nathan J. Robinson[2,3], Gabriela Blanco[4], Pilar Santidrián-Tomillo[5], Frank V. Paladino[1,2]

[1]Indiana-Purdue University Fort Wayne
[2]The Leatherback Trust
[3]Purdue University
[4]CONICET
[5]IMEDEA

Sea turtles often congregate in near-shore habitats during the nesting season. By comparing the inter-nesting behavior of turtles from different beaches, we can start to determine how they respond to different conditions. This can provide insights into resource use in sea turtles and their adaptability to environmental variability. We used satellite telemetry to investigate the inter-nesting behavior of two cohorts of green turtles from nesting beaches that are 50 km apart on beaches in Pacific Costa Rica (playas Cabuyal, CAB, and Nombre de Jesús, NDJ). Data collection began in 2007 at NDJ and continued through 2009; data collection at CAB began in 2012 and continued through 2015. We successfully recorded inter-nesting movements for 22 turtles (n=9 NDJ, n=13 CAB) and dive behavior was collected on eight turtles (n=3 NDJ, n=5 CAB). The turtles had inter-nesting intervals of 12±1.4 days for NDJ and 15.4±2.9 days for CAB, which is in the normal range observed for this species. We analyzed habitat-use using a kernel density analysis in ArcGIS, and found that of the average home ranges from the different beaches were similar; however individual movements were significantly different (ANOVA, F1,20=15.06 P=0.001; R 3.3). Summary dive data indicate that the main difference between cohorts was how they used surface water. We found that 80% of NDJ dives remained in the top 5 meters of the water column, twice that of dives from CAB, at 43%. The surface water, being defined as 2 meters or shallower; turtles from NDJ had 33% of dive

time spent in these waters, four times that of CAB, at only 8%. Dive durations ranged between 0 and 60+ minutes, with 88% and 92% of dives being 30 minutes or shorter for NDJ and CAB, respectively. All turtles showed similar daily activity trends, with diurnal dives being deeper than nocturnal dives. These results indicate that turtles nesting on Nombre de Jesús traveled less distance, and dove to shallower depths with higher surface time compared to turtles at Cabuyal, while dive duration, average area use and daily dive patterns were similar. Around Nombre de Jesús the ocean is shallower along the shoreline, while Cabuyal is adjacent to the Gulf of Papagayo and has deep offshore water and a very shallow thermocline. The variability in dive behavior between beaches seems to be a direct response to the bathymetry of the coastline and temperature of the water at depth.

COMPARATIVE JUVENILE GREEN SEA TURTLE GROWTH RATES AT DISTINCT MARINE ENVIRONMENTS

Andrew G. Crowder[1,2], Michael S. Cherkiss[2], Thomas H. Selby[2], Devon A. Nemire-Pepe[1,2], Clayton Pollock[3], Zandy Hillis-Starr[3], Mandy Tumlin[4], Kristen M. Hart[2]

[1]*Cherokee Nation Technologies*
[2]*U.S. Geological Survey*
[3]*U.S. National Park Service*
[4]*Louisiana Department of Wildlife and Fisheries*

Green turtles, *Chelonia mydas*, are found in tropical and subtropical inshore and nearshore waters across the globe. In the North Atlantic, locations range in U.S. and Gulf of Mexico waters from Massachusetts to Texas, Puerto Rico, and the U.S. Virgin Islands. Our research spans across this region and we have established long-term mark-recapture monitoring studies in the marine protected areas of Dry Tortugas National Park (DRTO; 2008-2016) and Buck Island Reef National Monument (BUIS; 2012-2016). In 2014 we began a mark recapture study in a non-protected site at Belle Pass off of Port Fourchon, Louisiana (BEPA), a site with intense anthropogenic pressures. We calculated green turtle growth rates for turtles occupying three distinctly different marine habitats. Growth rates of an individual animal reflect the correlation between the biotic and abiotic factors of its surrounding environment. Green turtles, the largest of all the hard-shelled sea turtles, rely on a primarily herbivorous diet, making their habitat critical for health and survival. Analysis of 125 juvenile green turtle growth rate data (DRTO: N=41; BUIS: N=74; BEPA: N=10) showed mean growth rates of 5.78 cm/year, 3.32 cm/year, and 5.05 cm/year at the three sites, respectively. The relatively small sample size and short recapture interval at the Belle Pass site is due to the recent start of the project, compared to our other sites (mean duration between recaptures: DRTO 2.07 years, BUIS 2.27 years, BEPA 0.66 years). This could be potentially inflating the growth rate at Belle Pass, requiring continued research and monitoring. Additionally, the average straight carapace length of the turtles at each site varies: DRTO 33.2 cm, BUIS 41.2 cm, BEPA 29.8 cm. Since smaller green turtles generally grow at faster rates than larger turtles, BEPA growth rates could be reflective of the smaller size class of turtles occupying that habitat, rather than more adequate resources. Algae has been observed to constitute the major diet items at BEPA, whereas seagrass represents major diet items for both DRTO and BUIS green turtles.

MARINE MACROALGAE IN DIET OF GREEN TURTLES (*CHELONIA MYDAS*) FROM ILHA GRANDE BAY, RIO DE JANEIRO STATE, BRAZIL

Rodrigo dos Santos Diaz[1], Humberto Mas Gitirana[2], Maria Teresa Menezes Széchy[2], Gisele Lôbo-Hajdu[2]

[1]Laboratório Integrado de Ficologia da Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, Brasil.
[2]Laboratório de Genética Marinha da Universidade do Estado do Rio de Janeiro (UERJ), Rio de Janeiro, Brasil.

Although marine turtles are considered opportunist species, each species has a preferential feeding habit, which becomes more restrictive along the advent of adulthood. From a general perspective, green turtles (*Chelonia mydas*) are predominantly herbivorous, although their diet may vary according to the food availability. Knowing the feeding ecology of turtles is crucial for their conservation, since it is directly related to the state of health of the animals and to the habitat they live in. The PROMONTAR-ANGRA Project, with support from Eletrobras Eletronuclear – Nuclear Power Plant Company, was developed aiming at monitoring and investigating the occurrence of marine turtles stranded ashore in Ilha Grande Bay (IGB), encompassing municipalities of Angra dos Reis and Paraty, south of Rio de Janeiro State, Southeastern Brazil. On that Bay, particularly, the occurrence of green turtles was frequent. Based on the points mentioned above, the objective of this study was to evaluate marine macroalgae found in the digestive tract of green turtles rescued stranded on the beaches, followed by necropsy, in the scope of PROMONTAR-ANGRA. We evaluated the content of the digestive tract of 46 green turtles, in order to determine species composition, number of species, and frequency of occurrence of marine macroalgae species. The content inside intestinal portions was disregarded due to their decomposition stage. We identified 67 macroalgal species: 38 Rhodophyta, 13 Heterokontophyta/Phaeophyceae, and 16 Chlorophyta. All identified species have been already listed for IGB, which may indicate that the turtles could be feeding within that region prior to their death. That value is close to the mean value for number of species described for taxonomical surveys on rocky shores in this same region (considering 15 scientific publications). Taking into account the frequency of occurrence of macroalgae in the digestive tract of the analyzed specimens, 4% of the species were constant (≥50%): *Ceratodyction variabile*, *Ceratodyction planicaule*, and *Chondracanthus acicularis*, all of them from Rodophyta phylum and classified as corticated macrophyte (morphological type). Phycologists, investigating the macroalgal community structure on IGB, have also described such species as the most frequent on the shallow subtidal region of rocky shores. Among other macroalgal species eaten by turtles, 7% were considered as accessory (25-50%); and 89%, as accidental (<25%). Studies on feeding diet of green turtles must be complemented by other type of investigations, for example, through field observations and measurement of availability of food resources along time scale, in order to understand interactions between turtles and habitats, and to estimate their population health conditions.

BLOBS VS. HULLS: REFINING SEA TURTLE FORAGING HOME RANGES AROUND COMPLEX COASTLINES USING STATE-SPACE MODELING AND NON-PARAMETRIC UTILIZATION DISTRIBUTIONS*

Andrew DiMatteo[1], Gwen Lockhart[2], Susan G. Barco[2]

[1]*CheloniData LLC*
[2]*Virginia Aquarium & Marine Science Center*

Accurate characterization of sea turtle foraging home ranges has important implications for sea turtle conservation and management, both at the individual and population level. Sea turtle home ranges are commonly examined by creating utilization distributions (UDs) from ARGOS and GPS satellite tracking data. Satellite locations of sea turtles are irregular in time due to such factors as animal submergence, patchy satellite coverage, and environmental conditions, which can lead to bias in home range analysis even before the errors associated with ARGOS and GPS locations are accounted for. Additionally, linear tracks associated with migratory behavior or foraging behavior in areas with complex coastlines often confound parametric approaches to estimating home ranges. Parametric approaches such as HREF or least square cross validation perform poorly with linear features (over estimating the width of the home range or giving erroneous results) and often overlap land when a turtle is foraging in close proximity to the shore – the classic home range 'blob'. Simply removing the portions of the 'blob' that overlap land makes comparison to individuals foraging offshore infeasible and mischaracterizes the proportion of 'core' home range to total home range. The combination of two analytical techniques can mitigate many of these problems, leading to better characterization of sea turtle home ranges near complex shorelines. First, state space modeling can smooth satellite tracks into even time steps, taking into account ARGOS and GPS location error, which minimizes spatial autocorrelation issues inherent with irregular time steps. The same model can also characterize smoothed locations as either foraging or migratory behavior, allowing the removal of linear sections of the track associated with migration. Second, utilization distributions created using the non-parametric localized convex hull (LoCoH) method perform better than parametric methods at naturally avoiding barriers and recognizing holes in UDs because they are made from a series of convex hulls created from sequential sets of locations within the data set. When applied to sea turtle foraging locations only, they perform better than parametric approaches at avoiding land. Here we present a case study of a population of loggerhead turtles tagged in Chesapeake Bay, a large, complex estuary, which utilize foraging grounds both inside and outside the bay. By applying a state space model to identify foraging locations and creating UDs using adaptive LoCoH, individual foraging home ranges were created that largely do not overlap land and provide a more realistic measure of home range (compared to parametric approaches). Creating an index that combined individual home ranges allowed for examination of important foraging areas at the population level, with implications for species management and mitigation of potentially harmful activities.

SUBSURFACE OBSERVATIONS OF LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) WITH AN AUTONOMOUS UNDERWATER VEHICLE (AUV)*

Kara L. Dodge[1], Amy L. Kukulya[2], Erin Burke[3], Mark F. Baumgartner[1]

[1]Biology Department Woods Oceanographic Institution Woods Hole MA 02543 USA
[2]Oceanographic Systems Laboratory Woods Oceanographic Institution Woods Hole MA 02543 USA
[3]Massachusetts Division of Marine Fisheries New Bedford MA 02740 USA

Despite significant progress in the management of pelagic fisheries with respect to sea turtle bycatch, the impact of coastal fisheries on sea turtles remains poorly studied. In shelf waters off the Northeast USA, fixed gear fisheries and aquaculture operations overlap with important leatherback turtle (*Dermochelys coriacea*) foraging habitat, and entanglement in vertical lines is a well-documented source of leatherback injury and mortality. Attempts to address this source of bycatch through gear modifications have been hindered by a lack of empirical information on turtle behavior in the vicinity of fixed fishing gear. Recent advancements in autonomous underwater vehicles (AUVs) now make it possible to study the subsurface behaviors of sea turtles. To investigate leatherback fine-scale behavior in gear-dense habitat off Cape Cod, Massachusetts, USA, we tagged and followed four leatherback sea turtles with a REMUS-100 AUV between 17 September and 13 October 2016. The AUV was equipped to locate, follow and film the tagged turtles, collecting footage with six high definition video cameras. We also used an animal-borne transponder affixed with cameras to record behavior from the turtle's perspective. Since turtle behavior is likely a response to habitat factors, we collected concurrent in situ oceanographic data (temperature, salinity, chlorophyll fluorescence) throughout the water column using a second REMUS-100 AUV equipped with a fast response conductivity-temperature-depth (CTD) instrument and fluorometer/turbidity sensor. Our four missions generated 17 hours of AUV localization data and video, 14 hours of bio-physical oceanographic data, and 12 hours of turtle-borne camera footage. These data are currently being analyzed to characterize the diving behavior and foraging ecology of leatherback turtles and to assess how diving behavior mediates entanglement risk. Our study demonstrates that an AUV can successfully track and image leatherback sea turtles feeding in a coastal environment, resulting in new observations of three-dimensional subsurface behaviors and habitat use.

JUVENTLE HAWKSBILL TURTLES PREFER THE HIGH RUGOSITY FOUND IN THE ARTIFICIAL REEF DOLOS OF THE CYRIL E. KING RUNWAY

Scott Eanes[1]

[1]University of the Virgin Islands

The marine habitat created by the extension of the Cyril E. King (CEK) runway on the island of St. Thomas, USVI is an artificial reef habitat that has become an important developmental area for critically endangered, juvenile and sub-adult hawksbill sea turtles. The use of large “jacks” or dolos in some areas created a variety of benthic habitats along the submerged portions of the runway extension. The extension created an artificial fringing reef with high rugosity in areas where dolos were used. Benthic surveys examined two factors along the runway, composition of sessile benthic communities, and crevice size in an effort to link hawksbill turtle hourly usage of the habitat to either factor. Five Vemco acoustic receivers were placed around the marine runway habitat to maximize acoustic coverage. Six hawksbill turtles were then captured and tagged acoustically with either a V13 or V16 acoustic (Vemco) tag, with two turtles being fitted with

depth tags. Turtles were tracked for a maximum of 200 days to a minimum of 100 days. The calculated hourly habitat usage shows a preference for runway sections with the largest crevice size, with one turtle found to spend 10 hours a day in the areas with high rugosity. Depth and benthic community composition results were found to be inconclusive. The use of dolos for marine construction in tropical waters may create an ideal habitat for critically endangered hawksbill turtles due to the large crevices created when compared to rock rubble construction.

USING FASTLOC-GPS TELEMETRY DATA TO ASSESS FINE-SCALE GREEN TURTLE MOVEMENT AND IDENTIFY REMOTE SEAGRASS HABITAT IN THE INDIAN OCEAN*

Nicole Esteban[1], Jeanne A Mortimer[2,3],, Fredrik Christiansen[4], Pep Nogues[3], Pierre-Andre Adam[3], Graeme Hays[5]

[1]Swansea University
[2]University of Florida
[3]Island Conservation Society
[4]Murdoch University
[5]Deakin University

Chagos Archipelago in the central Indian Ocean hosts one of the world's largest marine protected areas, and some of the most remote and pristine tropical marine ecosystems anywhere. During 2012-2016, 18 post-nesting green turtles (*Chelonia mydas*) were satellite tracked using Fastloc-GPS telemetry from Diego Garcia atoll and travelled to foraging grounds ranging in distance between 75 and 4,000 km from their Diego Garcia nesting habitat. Four of the green turtles settled within the Chagos Marine Reserve and provided the first evidence of foraging habitat for adult green turtles in the Chagos Archipelago. Ten of them settled on feeding grounds in Seychelles, and four found foraging habitat along the east coast of continental Africa. We analysed fine-scale movement of the green turtles in different foraging areas in the Indian Ocean and were able to show that individuals exhibit both diel and seasonal patterns in activity and home range size. At night, turtles had separate, smaller home ranges and lower activity levels, suggesting they were resting. In daytime, home ranges were larger and activity levels higher, indicative of active feeding. Ground truthing surveys were recently conducted at five of the foraging sites (day and night-time sites) on the Great Chagos Bank (GCB) that were identified by this satellite tracking study. At day-time sites, extensive meadows of seagrass *Thalassodendron ciliatum* were identified at depths ranging from 23-30 m along the shallowest parts of the largely unsurveyed GCB. Night-time sites were found in deeper reef areas. The Great Chagos Bank is the world's largest living coral atoll; and seagrass habitat had not been previously reported there. Foraging habitats were ground truthed for two turtles that migrated to Seychelles, i.e. at Providence Bank and at Farquhar Atoll. Depth readings were taken using a fathometer and benthic habitats were viewed from the surface using a glass bottomed bucket at respectively, 60 and 50 GPS locations on Providence Bank, and 15 and 10 locations at Farquhar Atoll. In addition, SCUBA surveys were conducted at three locations on Providence Bank. In contrast to the situation at GCB, night time sites surveyed in Seychelles tended to be shallower than those used by turtles in the daytime. As at GCB, however, most foraging habitat examined at Providence Bank comprised extensive meadows of T. ciliatum, but under 10 m deep. Spatiotemporal variations in habitat (seagrass) quality are likely having a bottom-up effect on the diurnal and seasonal pattern in home range sizes. We highlight the value of the new generation of Fastloc-GPS Argos tags for resolving details of sea turtle movements at small scales.

TROPHIC ECOLOGY OF THE OLIVE RIDLEY SEA TURTLE IN THE EASTERN PACIFIC OCEAN

Christine Figgener[1], Joseph Bernardo[2], Kim Reich[3], Pamela T. Plotkin[4]

[1]Marine Biology IDP, Texas A&M University, College Station, TX, USA
[2]Department of Biology, Texas A&M University, College Station, TX, USA
[3]Department of Biology, Palm Beach Atlantic University, West Palm Beach, FL, USA
[4]Department of Oceanography & Texas Sea Grant, Texas A&M University, College Station, TX, USA

In recent years, stable isotopes have become a powerful tool to investigate the habitat-use and foraging strategies and patterns of species otherwise difficult to study, including highly migratory marine species, such as sea turtles. Studies on adult female *Caretta caretta*[1, 2], *Dermochelys coriacea*[3], and *Chelonia mydas*[4] have revealed intraspecific foraging dichotomies and trichotomies, along with a bimodal or polymodal difference in morphology and reproductive output. Foraging strategies differ mainly between coastal and oceanic, with coastal foragers having larger body size and a higher reproductive output than oceanic foragers. To date no study has been published investigating the foraging ecology of olive ridley sea turtles (*Lepidochelys olivacea*) using stable isotopes. A previous satellite telemetry study revealed a predominantly pelagic foraging migration among mass-nesting females in Costa Rica, and also observed individuals travelling several thousand kilometers into the Pacific currents and gyres, as well as changes in migratory routes between years after an ENSO event [5]. However, all of these turtles were tracked from a single locality. To examine the possibility that there is geographic variation in foraging ecology, we collected skin samples from female olive ridleys nesting at multiple beaches along the Pacific coast of Costa Rica. We measured the stable carbon and stable nitrogen concentrations in these samples to test our hypothesis of a foraging dichotomy. Samples collected in the 2014/15 nesting season from five different nesting beaches (Nancite, Naranjo, Islas San Jose, Cabuyal, and Playa Grande), revealed a significant difference in stable carbon signatures among nesting beaches (ANOVA, Prob>F=0.043), but no difference in stable nitrogen. Nancite beach had a less depleted mean signature in carbon in comparison to the rest of the beaches and was significantly less depleted than Playa Grande (ANOVA post hoc, Student's pairwise t-test, p=0.0071). Stable carbon concentrations vary greatly between oceanic and coastal waters due to their base-line producers differing preferences for 12C. More depleted carbon signatures are an indicator for oceanic foraging.

THE JOURNEY OF HOMEROUS, AN INJURED LOGGERHEAD TURTLE RELEASED AFTER 9 YEARS AT LAMPEDUSA RESCUE CENTRE

Daniela Freggi[1], Abigail Marven[2], Julien Pfyffer[3]

[1]Lampedusa sea turtle rescue center,
[2]University of Surrey
[3]Octopus Foundation

Homerous is a female Loggerhead sea turtle, *Caretta caretta*, who was brought to Lampedusa Turtle Rescue Center in May 2008. Clinical investigations have shown she had suffered massive injury to her carapace due to the potential collision with a boat, resulting in the paralysis of the back flippers. But in reality her release was compromised by the fracture of the humerus of her front right flipper making her swimming slow and always bending to the left. The first proposal was to transfer Homerous to an aquarium, where

she would be able to live out her life and serve an educational purpose. However due to the complex administrative process of our legislation, this proved extremely difficult and was not possible. Therefore Homerous remained in the Rescue Center, and we decided to undertake weekly sessions of physiotherapy in the open sea using a jacket connected to a line of 70 m, in order to improve her swimming ability. This "rehabilitation therapy" took part over 5 summers, involving lots of volunteers, and in the last 2 years a clear improvement of her swimming was observed. Thanks to the precious support of the Swiss Octopus Foundation, providing a public campaign for a satellite tracker, Homerous was finally released on October 26th 2016. The aim of this experience is to determine the possible response of a turtle who has been in captivity for a long length of time, and of course to follow her journey, possibly correlated to wind direction and the currents of the Mediterranean. From the preliminary satellite findings of the first months, the tracking showed a southern movement towards the Tunisian coast, correlating with the current patterns in this area, hopefully known to be rich feeding grounds for Loggerheads. The case of Homerous is an example of the cooperation of many people, with different expertise, working together for the conservation of sea turtles: Homerous quickly became an icon in social media, developing public awareness.

INFERRING SHARK-TURTLE DYNAMICS WITH ACOUSTIC TELEMETRY AND SOCIAL NETWORK ANALYSIS*

Mariana M. P. B. Fuentes[1], Anthony Gillis[1], Tristan Guttridge[2], Simona Ceriani[3], Jeffrey A. Seminoff[4], Matthew Smukall[5], Maurits Van Zinnicq Bergmann[6], David Jacoby[7]

[1]*Florida State University*
[2]*Bimini Biological Field Station Foundation*
[3]*Florida Fish and Wildlife Conservation Commission Fish and Wildlife Research Institute*
[4]*NOAA-Southwest Fisheries Science Center*
[5]*University of Alaska Fairbanks*
[6]*Florida International University*
[7]*Zoological Society of London*

Predator–prey interactions play a major role in determining the structure and function of ecological systems, by directly and indirectly influencing behavior, distribution, and habitat choice. Thus, understanding the mechanisms and drivers of predator–prey interactions is important for predicting community dynamics and to inform management. However, in many systems, predator–prey interactions are challenging to observe and researchers can only infer predation. This is true for shark interactions with sea turtles, where the influence of shark predation on sea turtle behavior, population dynamics is poorly understood. At sea, the most common predators of adult sea turtles are sharks, with documented predation by bull, white and tiger sharks. Despite knowledge of sharks predating on sea turtles, little is known about how these predators influence turtle behaviors and population dynamics. The most in-depth studies of shark-turtle interactions explore and quantify the effects of shark predation on sea turtles by measuring the frequency of shark-inflicted injuries on turtles, and by capturing turtles and sharks in areas where they co-exist and making inferences based on the habitats within which they were captured, and overlap between habitat use, health and food availability. Despite an overlap in the distribution of shark species known to predate sea turtles, so far only one study has examined the home range and spatiotemporal overlaps of sharks and turtles (adult female green turtles and tiger sharks in Northwest Atlantic, USA). Simultaneous tagging of sharks and turtles can provide a more detailed understanding of the frequency and duration of interactions between these taxa and insights into habitat overlap, the influence of predator encounters on habitat use decisions and insights into prey and predator behavior in areas that they co-exist. Here we use acoustic telemetry and social network analysis to elucidate predator-prey interactions between sharks and turtles. For this, we concurrently deployed long-life acoustic transmitters (V16 and V13Vemco transmitters) in 44 juvenile

green turtles and 86 large sharks > 2m (27 tiger,13 bull, 20 lemon, 10 hammerhead and 16 nurse sharks) in Bimini, Bahamas, and tracked their movements via an array of 57 acoustic receivers (VR2 W Vemco hydrophone receivers). Social structure both within and between species, the number of clustering events at each location, and chronology of arrival time between individuals and duration of co-occurrences were determined using recently developed Gaussian mixture modelling approaches. The applicability and limitation of this approach to explore the interactions between turtles and sharks is discussed.

THE FEEDING HABITS OF SEA TURTLES INFLUENCE THEIR REACTION TO ARTIFICIAL MARINE DEBRIS*

Takuya Fukuoka[1], Misaki Yamane[1], Chihiro Kinoshita[1], Tomoko Narazaki[1], Greg J. Marshall[2], Kyler J. Abernathy[2], Nobuyuki Miyazaki[3], Katsufumi Sato[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo
[2]National Geographic Remote Imaging
[3]Japan Marine Science Foundation

Ingestion of artificial debris is considered a significant stress for wildlife, including sea turtles. To investigate how turtles react to artificial debris under natural conditions, we deployed animal-borne video cameras on loggerhead and green turtles and, additionally, conducted feces and gut content analyses from 2007 to 2015. Frequency of occurrences of artificial debris in feces and gut contents collected from loggerhead turtles were 35.7% (10/28) and 84.6% (11/13), respectively. Artificial debris appeared in all green turtles feces (25/25) and gut contents (10/10), and green turtles ingested more debris (feces; 15.8 ± 33.4 g, gut; 39.8 ± 51.2 g) than loggerhead turtles (feces; 1.6 ± 3.7 g, gut; 9.7 ± 15.0 g). Video records (60 and 52.5 hours from 10 loggerhead and 6 green turtles, respectively), showed turtles encountered 46 artificial debris and ingested 23 of them. The encounter-ingestion ratio of artificial debris in green turtles (61.8%) was significantly higher than that in loggerhead turtles (16.7%). Loggerhead turtles frequently fed on gelatinous prey (78/84), however, green turtles mainly fed on marine algae (156/210), and partly consumed gelatinous prey (10/210). Turtles seemed to confuse solo drifting debris with their natural diet, and omnivorous green turtles were more attracted by artificial debris.

EFFECTS OF A POWER PLANT CLOSURE ON HOME RANGES OF GREEN TURTLES IN A TEMPERATE FORAGING AREA

Suzanne E. Graham[1], Jessica J. Bredvik[2], Brendan P. Saunders[1], Robin LeRoux[3], Jeffrey A. Seminoff[3], Tomoharu Eguchi[3]

[1]Space and Naval Warfare Systems Center Pacific
[2]Naval Facilities Engineering Command Southwest
[3]NOAA Southwest Fisheries Science Center

Along the coast of southern California, San Diego Bay is one of two year-round foraging grounds for a population of approximately 60 East Pacific green turtles (*Chelonia mydas*) that has ongoing new recruits entering the area. The bay is an urbanized environment with anthropogenic inputs from industrial, military, and recreational activities. Between 1960 and 2010, a power plant operated in south San Diego Bay and discharged warm-water into an effluent channel. To better understand fine-scale movement patterns and potential home range shifts of green turtles in this area, we tracked 18 green turtles (7 pre-closure, 2007-

09; 11 post-closure, 2011-14) using Argos-linked GPS satellite transmitters. Turtles were tracked from 15 to 104 days (mean tracking duration = 50 days). Home ranges were constructed from 1052 pre-closure and 1222 post-closure filtered GPS and Argos-derived locations. These points were used in adehabitatHR for kernel density home range estimations that used least-squares cross validation for bandwidth selection. These estimates showed that green turtle home ranges increased in area by 105% (1.08 km2) and 33.3% (1.99 km2) for 50% and 95% Utilization Distributions (UD), respectively, since the power plant closure. Regardless of the power plant presence, turtles occurred mostly over eelgrass beds (*Zostera marina*). However, after the power plant's closure, the overlap of home ranges within eelgrass coverage increased by 1.09 km2 and 3.22 km2 for the 50% and 95% UDs, respectively. In recent years, monitoring efforts have indicated an increase in stranded green turtles in the bay. Given home range changes and habitat use patterns found in these movement data, our research efforts can help provide insights about increased prevalence of mortality in the bay. Future conservation efforts must continue to focus on an understanding of the distribution and movements of green turtles in the bay so that effective conservation and protective measures can be developed for this species.

IN SEARCH OF GREENER PASTURES: USE OF VIDEO FOOTAGE TO STUDY GREEN TURTLE (*CHELONIA MYDAS*) GRAZING BEHAVIOR*

Alexandra G. Gulick[1], Robert A. Johnson[1], Alan B. Bolten[1], Karen A. Bjorndal[1]

[1]Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida, Gainesville, FL, USA

Green turtles (*Chelonia mydas*) are the primary consumers of seagrasses worldwide and play an important role in determining the structure and function of seagrass communities. While our understanding of large-scale behavior and movement patterns of green turtles continues to grow (e.g., satellite telemetry studies), our knowledge of fine-scale foraging habitat-use patterns and grazing behavior is limited. Understanding the role of green turtle grazing in seagrass ecosystem processes is imperative to implementing ecosystem-based management plans, especially in light of global seagrass declines and documented increases of many green turtle populations. Using stationary benthic video cameras, we investigated green turtle grazing behavior in a naturally grazed seagrass ecosystem at Little Cayman, Cayman Islands. Grazed seagrass meadows at this location are dominated by *Thalassia testudinum* (mean depth ~1m) and support a small population of juvenile green turtles. Video cameras (GoPro Hero 4, n = 4) were deployed daily during peak grazing hours, as weather allowed, in three turtle grazed plots (area = 40-70m2), from May to July 2016. We obtained 282 h of video footage from 106 camera deployments (28 deployment days). From the footage, we determined the number of turtles (identified by post-ocular scute patterns) maintaining each grazing plot, frequency and duration of grazing bouts, and estimates of intake rate from bite counts. We then assessed if these behaviors varied over time, between individuals, and with respect to seagrass characteristics of each of the grazed plots (plot area, shoot density, blade length and width, above-ground and below-ground biomass). Site-specific characteristics of seagrass meadows may play a significant role in determining the distribution, grazing patch use patterns and abandonment, intraspecific interactions, and foraging tactics of green turtles in coastal foraging areas.

RESIDENT OR TRANSIENT? GAINING GROUND ON THE FUNCTION OF NEARSHORE HARDBOTTOM FOR JUVENILE GREEN TURTLES (*CHELONIA MYDAS*) THROUGH COLLABORATIONS WITH THE FLORIDA ATLANTIC COAST TELEMETRY (FACT) ARRAY

Karen G Holloway-Adkins[1,2], Daryl S. Adkins[1,2], Eric A Reyier[2], Douglas M Scheidt[2]

[1]*East Coast Biologists Inc.*
[2]*IMSS-NASA Ecological Program*

We utilized a network of passive acoustic receivers (Florida Atlantic Coast Telemetry array; F.A.C.T.) that are currently installed along the nearshore coastal and inland waters of southeastern U.S. to determine the site fidelity of juvenile green turtles (*Chelonia mydas*) adjacent a highly developed coastline in Brevard County, Florida, USA. During the study period (2013-2015), we captured 63 new turtles that ranged between 22.5 - 40.7 cm straight carapace length (SCL)] and affixed acoustic transmitters on 15 of the larger juveniles (mean 29.9 cm SCL ± 1.7 SD). The minimum period of tracking data was 1 day and the maximum was 117 days. However, data from turtles that were re-captured (acoustic tagged or not) indicate that many of the turtles likely remained within the area for a year or more. Only one turtle was detected outside this hardbottom area at a receiver approximately 40km south of the study area. It was recaptured approximately 2 weeks later in the same area where it was originally captured and its tag was missing. Except for this one turtle that was detected briefly outside of our immediate study array area, none of the other tagged turtles were detected at nearby receivers. Acoustic-tagged turtles from other study area populations were also not detected within our array. Most of the turtles were detected at two or more receivers, however, the relatively large number of turtles recaptured within <50m from their original capture location indicate turtles exhibited high site fidelity at a micro-scale. It is likely that turtles remained adjacent to or near the hardbottom habitat for foraging and shelter. This is the first study to utilize acoustic telemetry to reveal movement patterns of juvenile green turtles in a high-energy environment. Advanced technology and improved methods of tagging should result in longer tag retention time and greatly improve tracking datasets in the future. These data are invaluable, especially in areas challenged with maintaining quality habitat in concert with coastal development.

JUVENILE HAWKSBILL AND GREEN SEA TURTLE DIVING AND ACTIVITY LEVELS SHOW STRONG DIURNAL PATTERNS IN BREWERS BAY ST THOMAS US VIRGIN ISLANDS

Paul Jobsis[1], Jon Jossart[1], Scott Eanes[1], Kari Gehrke[1]

[1]*University of the Virgin Islands*

Habitat use and movement patterns of juvenile sea turtles is one of the largest gaps in our understanding of these endangered animals. An excellent study site, Brewers Bay in St Thomas, US Virgin Islands is shared by both juvenile Hawksbill, *Eretmochelys imbricate*, and Green, *Chelonia mydas*, sea turtles, with more than 50 individuals of each species estimated to be in the small bay (<1km2). Over a two year period 12 Hawksbill and 9 Green turtles were tagged with Vemco V13 acoustic tags and their movements recorded throughout the bay by an array of 40 Vemco acoustic receivers. Dive depth and duration data was collected for 15,536 dives of 5 Hawksbill and 4 Green turtles whose Vemco tags were equipped with pressure sensors. Relative daily activity levels were determined by the number of receivers detecting an individual each hour.

The movement patterns showed both turtle species were more active during daylight hours. At night the turtles were less active and remained submerged for longer periods of time, Greens (n=4, average ± SD) 22.3 ± 7.7 min during the day and 35.6 ± 3.8 min at night, Hawksbills (n=5) 27.5 ± 8.6 min during the day and 53.0 ± 9.3 min at night. The change in dive duration most likely reflects a decrease in metabolic rate at night due to reduced activity levels. While both species showed this similar correlation in activity level and dive duration, patterns in dive depth were dissimilar between the species. Hawksbill turtles dove deeper during the day than at night (7.3 ± 2.7 vs 5.1 ± 1.7 m), while Green turtles showed the opposite patterns (3.9 ± 2.4 vs 6.4 ± 2.4 m). This may be explained by their different foraging and resting behaviors with Green turtles foraging in relatively shallow sea grass beds and Hawksbill turtles foraging on the bay's deeper natural and artificial reefs. Both dive duration and dive depth showed strong significant differences between day and night behaviors when tested with a Student's t-test. Water temperature varied little diurnally, and so is an unlikely driver of these differences in dive behavior and activity level. Lunar cycle and the expected lunar illumination may cause some differences observed in night time behavior in Green turtles. A better understanding of these endangered animals' habitat requirements and behavioral differences will aid in the selection of proper protected areas for juvenile Hawksbill and Green turtles.

GREEN TURTLES AND BLUE CARBON: EFFECTS OF GRAZING ON SEAGRASS MEADOW CARBON DYNAMICS*

Robert A. Johnson[1], Alexandra G. Gulick[1], Alan B. Bolten[1], Karen A. Bjorndal[1]

[1]*Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida, USA*

Seagrass meadows are some of the most productive ecosystems in the world and are important sites of blue carbon storage. Currently, seagrass systems are being lost at an alarming rate due to anthropogenic and natural disturbances. Across much of their global range, green turtles (*Chelonia mydas*) feed primarily on seagrasses. Successful conservation efforts have led to increasing green turtle populations in some areas. It is necessary to understand the effects that increased green turtle grazing has on the carbon sequestration capacity and ecosystem functioning of seagrass meadows within the context of globally declining seagrass area. In a seagrass manipulation experiment, we simulated green turtle grazing in a meadow in Little Cayman (Caribbean) to investigate how green turtle grazing affects carbon dynamics in coastal habitats. Using benthic incubation chambers, we measured rates of community production and respiration in both clipped (simulated grazing) and reference plots over twelve weeks. Simulated grazing by green turtles resulted in reduced rates of seagrass production. However, even with severely reduced biomass, clipped areas remained autotrophic, with metabolic rates similar to those of nearby areas that were naturally, actively grazed by green turtles. These results demonstrate that even under increased grazing pressure from green turtles, seagrass ecosystems are still capable of functioning as carbon sinks.

THE ANALYSIS OF DIGESTIVE TRACT CONTENTS ON GREEN SEA TURTLES (*CHELONIA MYDAS*) AT CHICHIJIMA IN THE OGASAWARA ISLANDS

Takahiro Kasai[1], Yumi Ohashi[1]

[1]*TUMSAT Sea Turtle Research Collegium*

The Ogasawara Islands one of the prominent spawning regions and nesting areas for green sea turtles in Japan. Sea Turtle Research Collegium of Tokyo University of Marine Science and Technology has been

sampling digestive tract contents of green turtles Chichijima in the Ogasawara Islands, and observing the variations of the contents with cooperation of Everlasting Nature of Asia Certified NPO (ELNA) since 2013. We collected esophageal, gastric and intestinal contents, identified their orders and measured their wet weights. The purpose of this study is to clarify the uninvestigated feeding ecology of the mating season of green turtles. In this year, we divided the datas from 2013 to 2016 and labeled them as "esophageal and gastric contents" and "intestinal contents" and analyzed washed weights of algae with cluster analysis. Also, even among them, we focused attention on marine litters and cephalopod beaks. As a result of analyses of algae containing esophageal and gastric contents, it did not show any changes year and year, however there was a group that showed a high degree of similarity on compositions of algae which were found in every individual. Also, we analysed appearance frequencies of intestinal contents of 2016. The result of esophageal and gastric contents was like that of intestinal contents. Moreover, we made mention of marine litters which were found from intestinal contents from 2014 to 2016. The appearance and frequency of white and transparent marine litters were relatively high. It is reported that green turtles, which feed on floating algae and jellyfishes on the sea surface, accidentally swallow marine litter more than other species of sea turtles. (T.Fukuoka et al ., 2016) From the report, it is considered that green turtles selectively accidentally swallow white and transparent marine litters whose colors are close to jellyfishes. Also we identified cephalopod beaks with "The manual of valuation of cephalopod beak "and "Cephalopod Beak Guide for the Southern Ocean". As a result of that, we confirmed bathybic Histioteuthidae, Ommastrephidae and Sepioidea from the beaks of green turtles (n = 4) in 2016. It is known that Black-footed albatross (Phoebastria nigripes) which live in the sea near the Ogasawara Islands feed on Ommastrephidae that live in the vicinity of the depth of 200 meters. Histioteuthidae is known that they emerge in the vicinity of sea surface in the night, and some of them which get weak because of the feeding activity of whales are found in the vicinity of sea surface. It is thinkable that they have a lot of opportunities to feed on that kind of cephalopods in the sea near the Ogasawara Islands.

HISTORICAL DATA FROM LONG TERM MARINE MAMMAL SURVEYS OFF SOUTHERN CALIFORNIA PROVIDE AN IMPORTANT SOURCE OF AT-SEA JUVENILE SEA TURTLE SIGHTINGS

Erin Keene[1,2], Erin Falcone[2], Annie Douglas[1]

[1]Cascadia Research Collective
[2]Marine Ecology and Telemetry Research

Marine mammal surveyors often opportunistically document other species during surveys, which can provide useful information for a variety of species that are otherwise difficult to study in open waters. Casual observations of "dinner plate" sized Loggerhead sea turtles (*Caretta caretta*) by marine mammal researchers in 2015 off Southern California, near San Clemente and Santa Catalina islands, prompted a review of historical sighting data from the region to determine if these turtles had been noted during previous surveys as well. This study reviewed all sighting archives from Cascadia Research Collective (Olympia, WA) and Marine Ecology and Telemetry Research (Seabeck, WA) along the US West Coast from 2000-present for observations of sea turtles and confirmed any species identifications through photographs and descriptions. Sightings of Leatherback (*Dermochelys coriacea*), Green (*Chelonia mydas*), and Loggerhead sea turtles were confirmed in the Southern California Bight and many sightings included notes on individual behavior, such as feeding and diving. Observations of "dinner plate" sized individuals, typically associated with juvenile sea turtles, were only noted for Loggerheads in more recent years. Although sea turtles were likely only documented in clear weather in the absence of focal marine mammal species in these surveys, these opportunistic data sources provide vital information regarding sea turtle presence and behavior in offshore areas not typically surveyed for small turtles, where dedicated vessel or

aerial surveys would be cost prohibitive. This study has provided valuable sightings from the data-deficient "lost years" of juvenile turtles at sea, and opportunistic data collection during marine mammal surveys should be encouraged.

EPIBIONTS OF EASTERN ATLANTIC LOGGERHEADS

Ana Liria-Loza[1]

[1]*University of Las Palmas de Gran Canaria (ULPGC)*

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 colonized the 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 was found on the juvenile loggerheads of 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 most important species was analysed, to look into the behavior and habitat preferences of these juvenile loggerheads in the area. An interesting interaction was found between the epibiont species and the turtles, with two sea turtle specific species (*P. carettia* and *P. chelonophilus*), one specialized on marine vertebrates (*P. hexastylos*), and some flotsam specialists like *P. minutus*, *L. anatifera*, *C. virgatum*, *C. andreae*, and *F. pinnata* (this last specie 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.

MAGNETIC NAVIGATION AND GEOMAGNETIC IMPRINTING IN SEA TURTLES*

Kenneth J. Lohmann[1], Nathan F. Putman[2,3], Roger Brothers[1], Catherine Lohmann[1]

[1]*University of North Carolina*
[2]*University of Miami*
[3]*NOAA Atlantic Oceanographic & Meteorological Laboratory*

Sea turtles are among the most impressive navigators in the animal kingdom. As hatchlings, turtles that have never before been in the ocean establish unerring courses towards the open sea and then maintain their headings after swimming beyond sight of land. Young turtles follow complex migratory pathways that often lead across enormous expanses of seemingly featureless ocean. Older juvenile turtles, as well as adults, are able to navigate long distances between specific locations such as areas used for feeding and reproduction. A lengthy series of experiments conducted over the past three decades has unraveled many of the navigational mechanisms used by sea turtles. Although turtles, like other migratory animals, exploit multiple sensory cues to guide their movements, research suggests that magnetoreception – the ability to detect Earth's magnetic field – is the central element of a sea turtle's ability to navigate long distances through the open sea. The geomagnetic field, unlike other cues, is present both night and day, is unaffected by weather and season, and exists everywhere in the ocean, regardless of depth. Sea turtles exploit Earth's field not only as a directional or compass cue, but also as a source of positional or 'map' information. For

example, hatchling loggerheads begin their first migration with a 'magnetic map' in which regional magnetic fields function as open-sea navigational markers, eliciting changes in swimming direction at crucial points in the migratory route. Older juvenile turtles use similar magnetic maps to facilitate navigation to specific geographic destinations. Finally, recent findings indicate that sea turtles imprint on the magnetic field of their natal areas and use this information to return years later as adults. The ability of sea turtles to detect magnetic fields not only explains much of the navigational behavior of turtles, but also reveals previously overlooked threats to the welfare of turtles that may arise from anthropogenic magnetic fields along beaches and in the marine environment.

DESCRIPTION OF THE FEEDING AREA OF GREEN TURTLE (*CHELONIA MYDAS* LINNAEUS 1758), IN VILLAMAR, TUXPAN; VERACRUZ

Edson Lugo Olguin

The green turtle *Chelonia mydas* as a cosmopolitan species and with protection status as endangered by the International Union for the Conservation of the Nature IUCN, nest in all the coast of Tuxpan, Veracruz, incres in the area of Villa Mar, a rocky coast area. For this reason the present work was realized to explain the presence of this species in the zone. The first records of C. mydas sightings were collected, morphometric data and weight of the individuals was taken by the fishermen and gave to the Turtle camp R-5 facilities of this locality. Ficoflora and fauna collections were also made, the profile of the rocky slope of the beach was determined, and a geo-referenced map of the site was carried out during the period April 2014-April 2015. Twenty-four green turtles , of which only eight were given morphometric and weight data, the size ranged from 27 cm to 45 cm (LT) with a mean of 38.3 cm, and a weight of 2.3 kg and 4.2 kg, with an average of 3.2 kg . The biotic composition consists of 23 species of which 17 were macroalgae belonging to the three existing phyla Rhodophyta represented by eight species, Chlorophyta consisted of five species, Ochrophyta represented by four species and six invertebrates Sessile of four phyllums Porifera with a single representative, Cnidaria with only one specimen, Arthropoda conformed by two species, Echinodermata with two species. Based on the literature reviewed and following the criteria proposed, it is evident that the presence of *C. mydas* is due to the algae prairies, for this reason the rocky beach is considered as a feeding area and therefore this area should be Protected and preserved under a management plan the next step of this investigation.

FIRST SATELLITE TRACKS OF SOUTH ATLANTIC SEA TURTLE 'LOST YEARS': TRANS-EQUATORIAL AND SEASONAL IMPLICATIONS FOR POPULATION CONNECTIVITY*

Katherine L. Mansfield[1], Milagros López-Mendilaharsu[2], Nathan F. Putman[3], Maria A. G. dei Marcovaldi[2], Alexander E. Sacco[1], Yonat Swimmer[4]

[1]*University of Central Florida*
[2]*Projeto TAMAR Fundação Pró-TAMAR*
[3]*Cooperative Institute for Marine and Atmospheric Studies & University of Miami*
[4]*NOAA Fisheries - Pacific Islands Fisheries Science Center*

In the South Atlantic Ocean, very few empirical data exist regarding the early dispersal and in-water behavior of oceanic stage sea turtles. In this ocean basin, a gyre system similar to that in the North Atlantic exists. The South Equatorial Current (SEC) forms the northern part of the South Atlantic Ocean Subtropical Gyre, carrying subtropical water from the Benguela Current region toward the Brazil shelf region around

14°S, where, unlike the Gulf Stream in the western North Atlantic, it bifurcates into two western boundary currents, the Brazil and North Brazil Currents (BC and NBC). Seasonal changes in these currents occur proximal to Brazil's most important sea turtle nesting beaches off the Bahia coast. These seasonal shifts in ocean circulation likely have far-reaching implications for the timing of hatchling dispersal and rookery productivity associated with Brazil's loggerhead populations. To address data gaps in the South Atlantic Ocean, using turtles originating from Brazilian rookeries, we: (i) characterized the satellite-tracked movements, habitat use, and dispersal of oceanic stage loggerhead turtles using novel telemetry techniques; (ii) tested for differences in dispersal patterns and habitat use during different periods (early, mid-, and late-) of the sea turtle hatching season; and (iii) experimentally tested and modeled whether the turtles passively drift with local ocean currents or actively disperse. From 2011-2012, we outfitted 19 laboratory-reared oceanic-stage juvenile sea turtles (10-26 cm straight carapace length) with 9.5-gram solar-powered satellite tags and tracked their movements for up to 120 days. Turtles were collected and reared at TAMAR in Praia do Forte, Bahia, and tagged turtles were released offshore of their natal beach. We strategically released tagged turtles early, mid- and late-hatching season to correspond to seasonal changes in regional ocean circulation. With each turtle release, we deployed passive oceanographic drifters to serve as controls in testing for active vs. passive turtle behavior (per Putman and Mansfield 2015). Tag and drifter data indicate that the net movement of turtles is an interaction between turtle behavior (e.g., orientation and swimming) and ocean circulation processes. Turtles released late hatching season were uniformly oriented northwards in a current regime that favored northward transport. By contrast, turtles with similar swimming behavior that were released into a more eddy-rich environment mid-hatching season (with stronger southward flows) remained in the vicinity of the release site. Those turtles transiting to the south early- and mid-hatching season, experienced stronger southward currents but appear to have oriented southeastward as well. Each of these observed movement patterns occurred in conjunction with the latitudinal shift in the bifurcation of the SEC into the BC and NBC that occurs during the loggerhead hatchling season. The timing of nesting and post-hatchling behavior exposes the young turtles to dynamic and seasonally-varying ocean conditions, resulting in a diversity of dispersal trajectories that lead some individuals into the northern hemisphere, and others further into the South Atlantic. Such diversity in migratory routes may ultimately buffer the population against environmental changes or even anthropologic threats in different oceanic regions, fostering population resiliency.

THE FIRST MINUTES AT SEA: AN INVESTIGATION OF THE CUE-DEPENDENT NAVIGATIONAL DECISIONS OF HATCHLING LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*)

Katherine R. Martin[1], Paulo H. Lara[2], Daniella Torres de Almeida[2] Alexandra M. Martin[3], Ashley Byun[3]

[1]*Department of Ecology & Evolution, Stony Brook University*
[2]*Projeto TAMAR*
[3]*Department of Biology, Stony Brook University*

Sea turtles use a variety of environmental cues to orient themselves both on land and at sea. It has been illustrated to varying degrees that these cues include light, wave action, and the magnetic field of the earth. In particular, hatchlings use light to orient themselves by positive phototaxis toward the ocean, which under natural conditions is the brightest object on the horizon. However, it is less clear what cues mediate their orientation behavior upon successfully reaching the ocean. Beginning in 2014, we began manually tracking loggerhead (*Caretta caretta*) hatchlings using GPS as they passed through the surf zone and into open water. The results demonstrate that hatchlings use different sensory cues to orient in the surf zone than in the open ocean, and that there is a cue switch during which time hatchlings may alternate between using

light and using magnetism or wave action as their primary cue. This highly dynamic behavior suggests that hatchling orientation ability is of considerable adaptive value in marine turtles. As the southern Atlantic coast of Brazil experiences increasing urbanization and concomitant light pollution, these results have important implications for the protection of loggerhead nesting beaches, and suggest that measures must be taken to minimize the effect of light pollution during both nest emergence and offshore movements.

MODELING MIGRATORY CORRIDORS AND FORAGING HOTSPOTS OF THE GREEN SEA TURTLE IN THE SOUTH WEST INDIAN OCEAN*

Mayeul Dalleau[1], Stephanie Kramer-Schadt[2], Jérôme Bourjea[3], Stéphane Ciccione[4], Volker Grimm[5]

[1]Kélonia
[2]Leibniz Institute for Zoo and Wildlife Research
[3]Institut Français de Recherche pour l'Exploitation de la Mer UMR MARBEC
[4]Kélonia
[5]Helmholtz Centre for Environmental Research UFZ German Centre for Integrative Biodiversity Research Halle JenaLeipzig

Environmental factors shape the spatial distribution and dynamics of populations. Understanding how these factors interact with movement behavior is critical for efficient conservation, in particular for migratory species. As an emblematic endangered species, green turtles have been intensively studied, with a focus on nesting, migration and foraging. Nevertheless, few attempts have integrated these three behaviors by considering the spatial configurations of foraging and nesting grounds as well as environmental heterogeneity. We developed a spatially-explicit individual-based model to investigate the impact of the environment on emerging migratory corridors and reproductive output and to thereby identify conservation priority sites for green turtles in the South West Indian Ocean (SWIO). The model integrates movement, nesting and foraging behavior. Results highlighted two connected provinces, in the north and the south of the Mozambique Channel A northern migration corridor emerged between the north of Madagascar and the northern coast of Mozambique. From the model, we could infer that the spatial distribution of nesting sites in this area and their central location relative to the regional feeding patches could explain the high densities of migrating turtles. The coastal areas of Africa and Madagascar bordering the north of the Mozambique Channel would be the most frequented one by turtles originating from numerous rookeries. This is consistent with known foraging locations from field observations and is also in agreement with the distribution of foraging areas of turtles satellite-tracked from the majority of the regional nesting sites. Another conclusion of the model was that numerous rookeries contribute to the nesters composition of the northern part of the SWIO, while the high level of frequentation of the southern part relies on a single rookery, Europa. This result correlates with results from a regional genetic analysis based on mitochondrial DNA. In the SWIO, direct take and coastal fisheries bycatch are a major threat; Looking at the model results, we could infer that high levels of bycatch and direct take reported along the coasts of Mozambique, Tanzania and Kenya might probably affect all sea turtle nesting populations of the region, and more specifically nesting populations from the north of the Mozambique Channel. High level of direct take also occurs in the southwest coast of Madagascar. The model showed, in accordance with genetics data, that adult individuals of the latter area were essentially issued from the nesting population of Europa Island. Conservation efforts in this area would consequently benefit preferentially this nesting population. Based on our results, we therefore propose specific guidelines for the regional conservation of green turtles as well as future research suggestions advancing spatial ecology of sea turtles. With the improving knowledge on sea turtle biology at individual scale, individual-based approaches should progress and become more integrative. The next logical step to improve these models requires a better ability to explicitly consider landscape and movement in a realistic context. The model presented here constitutes a first step. Our overall

modeling approach could also be useful for supporting the conservation of other migratory taxa. Although explorative, some of the ideas implemented should inspire spatial ecologists aiming at unifying movement ecology and population dynamics.

HOME RANGE AND HABITAT USE OF JUVENILE GREEN SEA TURTLES IN A SHALLOW TIDAL ENVIRONMENT

Meagan Gary[1], Annabelle Brooks[2]

[1]*Florida Atlantic University*
[2]*Cape Eleuthera Institute*

Home range is defined as the space occupied by an organism during daily activities, excluding migrations and atypical behavior. The home range of an organism can be further understood by: (1) learning what environmental factors are responsible for its selection, and (2) how the organism uses the habitat it occupies. Knowledge in both areas is vital to establish and maintain effective conservation measures, such as marine reserves. Juvenile green sea turtles (*Chelonia mydas*) recruit to coastal environments and display strong site fidelity to foraging grounds that serve as their home range. Green turtle home ranges are normally characterized by their food abundance, distribution, and quality. Additionally, green turtles have been shown to establish home ranges in tidal environments which may allow turtles to optimize foraging activities by exploiting the thermal and depth fluctuations associated with the tidal cycle. The shallow water habitats of the Bahamian Islands are important foraging sites for juvenile and adult green turtles as they contain abundant seagrass pastures as well as algal colonies associated with shallow tidal mangrove ecosystems. The goal of this study was to determine how turtles use their home range at a foraging site in The Bahamas, containing both a shallow tidal mangrove creek and an adjacent, deeper, open sound. To determine turtle home range locations, we attached acoustic transmitters to 9 individual turtles. Using active acoustic tracking, their daily movements were observed between July and December 2015. To examine turtle diet and food distribution, we conducted esophageal lavage on tracked turtles and mapped the vegetation coverage of the entire study site. Additionally, we placed temperature loggers throughout the study site to monitor how thermal fluctuations differed between habitats and throughout the tidal cycle. Home range data shows all of the turtles confined their movements to small, and often overlapping, areas (mean ± SD= 0.64 ± 0.24 km2). Tide state influenced individual turtle location within these home ranges; during flood tide periods more turtles were seen within the creek and overall closer to shore. Seagrass (*Thalassia testudinum*) dominated the stomach contents, ranging from 78.5% to 100% of the dry sample mass among turtles. Vegetation maps show that seagrass coverage was concentrated inside the tidal creek. There were large thermal fluctuations in the shallower habitats, influenced by the tides. Some of the smallest recorded home ranges of immature green turtles were documented in this study. Small home ranges may be possible for the turtles because higher temperatures can increase seagrass growth rates, allowing turtles to remain local. Foraging behavior is highly flexible and allows organisms to respond to changes in their feeding environment. This study provides insight into habitat use and behavior in developmental foraging grounds which can be crucial to developing marine reserves.

SATELLITE TRACKING THE MIGRATIONS OF POST-NESTING HAWKSBILL TURTLES IN SEYCHELLES

Jeanne A. Mortimer[1], Rainer von Brandis[1], George H. Balazs[4], Ryan Daly[1,2,3], Lara L Sousa[5,6], Peter Hitchins[6,7]

[1]Save Our Seas Foundation, Rue François-Bellot 6, CH-1206 Genève, Switzerland
[2]Seychelles Ministry of Environment, P.O. Box 445, Victoria, Mahé, Seychelles
[3]Department of Biology, University of Florida, Gainesville, Florida, USA
[4]National Marine Fisheries Service, Southwest Fisheries Science Centre, Honolulu Lab, Honolulu, Hawaii, USA
[5]Marine Biological Association of the United Kingdom, The Laboratory, Citadel Hill, Plymouth PL1 2PB, UK
[6]CIBIO-InBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Campus Agrário de Vairão, Universidade do Porto, 4485-661 Vairão, Portugal;
[7]Cousine Island Company, Victoria, Mahé, Seychelles

The Republic of Seychelles in the Western Indian Ocean hosts one of the four largest national populations of nesting hawksbill turtles (*Eretmochelys imbricata*) in the world. Although the Republic comprises more than 115 islands spread over an area of some 400,000 km2, most hawksbill nesting occurs in the eastern half of the country primarily on islands located on the relatively shallow Amirantes Plateau and on the Seychelles Bank which are separated from each other by some 40 to 350 km of deep water. Tracking of five post-nesting female hawksbills in 1998-99 from Cousin Island Nature Reserve, which hosts the largest hawksbill nesting population on the Seychelles Bank, demonstrated that all five of the tracked turtles remained on the Seychelles Bank settling at foraging sites ranging from only 20 to 175 km away from the nesting beach. Subsequent tracking of seven post-nesting females in 2014 from D'Arros Island, which hosts the largest hawksbill population in the Amirantes Group, also showed the preferred foraging habitat for all of them to be on the Seychelles Bank separated from the D'Arros nesting beach by deep water and straight line distances of 140 to 380 km. The actual distances travelled by turtles to reach those foraging habitats after departing D'Arros, however, ranged from 275 to 1,200 km, with speeds averaging 0.6 to 1.9 km/h. In conclusion, all twelve of the satellite tracked post-nesting Seychelles hawksbills showed a preference to forage on the Seychelles Bank, and an apparent reluctance to settle on the immediately proximate Amirantes Bank.

APPLY THE GIS TECHNIQUES TO DETERMINE THE SEASONAL CHANGE OF GREEN TURTLES (*CHELONIA MYDAS*) IN THE NEARSHORE WATERS OF A CORAL REEF ISLAND IN TAIWAN

Wan-Hwa Cheng[1], Ahmed Alhayki[1], Elija Flores[1], Xi Yang[1], I-Jiunn Cheng[2], Pin-Ze Huang[2], Dongyun Nam[1], Trisalyn Nelson[1]

[1]Arizona State University
[2]National Taiwan Ocean University

In-water observation of sea turtles has become a popular activity for tourists, while the anthropogenic threats can have a negative impact on the turtle populations. By delineating seasonal habitats associated with sea turtles, we can inform decisions that regulate human access to turtles throughout a year. Our goal

is to quantify seasonal change in the home range of green turtles around a coral reef island on the coast of Liuquiu Island, Pengtung County, Taiwan. Photo-ID techniques were utilized to identify 250 individual turtles in the water from 2014 to 2016. A kernel density estimator was applied to the more than 700 GPS locations for each turtle and the 50% and 95% home range generated for the population. For each home range the habitat conditions are quantified using environmental parameters (e.g., the sea surface and ocean temperature, bathymetry, and chlorophyll-a concentration) represented by geospatial data. In this study, the home ranges were generated based on the behaviors (forage and swim), and seasons. Results indicate that the size of 50% and 95% home ranges (km^2) are larger if those marine turtles were swimming compared to the size of home ranges when marine turtles were foraging. For most of the central features of GPS locations, which were recorded when marine turtles were foraged, fall within 50% home range area no matter what the season. Additionally, according to statistical results, chlorophyll-a concentration is close to being statistically significant ($p \cong 0.052$) associated to the size of 50% home range area. The ocean temperature is statistically significant associated to the size of 50% home range area ($p \cong 0.00015$) and the size of 95% home range ($p \cong 0.00015$). This study demonstrates how the relationship between the environmental parameters and home ranges varies across two- and three-dimensional space. Understanding how green turtles utilized their habitats and providing a suitable management strategy for the sustainable development of sea turtle ecotourism.

DIVE BEHAVIOR OF LEATHERBACK TURTLES DURING MIGRATORY CYCLE IN THE EASTERN PACIFIC*

Junichi Okuyama[1], Jeffrey A. Seminoff[1], Peter H. Dutton[1], Scott R. Benson[1]

[1]Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration

Leatherback turtles, *Dermochelys coriacea*, undertake broad oceanic movements. Recent satellite telemetry studies revealed that leatherback turtles showed cyclic migration between temperate and tropical waters in the north Pacific and the north Atlantic during the foraging period. In northern temperate waters, leatherback turtles were observed to spend the time foraging activity by previous studies, whereas the behavior in the tropical waters and in the migration corridors between two waters has not been well investigated. Here we investigated the dive behavior of leatherback turtles during the migratory cycle in the eastern Pacific. We used three types of dive data_time-at-depth data (N=28), intermittent dive data (N=4) obtained from ARGOS satellite transmitters, and continuous dive data obtained from recovered semi-archival tags (N=1). All dive data demonstrated that the mean dive depth was deeper with lower latitude and shallower in higher latitude. Deeper dives in the tropical regions allow turtles to expose cold waters, and consequently to thermoregulate. Therefore, this shift in dive depth with latitude may be associated with their thermoregulation. The continuous archival and intermittent dive data showed that wiggle dives (up-and-down undulations in the depth profile) which may associate with foraging (Fossette et al. 2008) were often observed in temperate waters along the California coast and in the equatorial eastern Pacific (EEP, 5°-15°N, 120°-150°W), while few observed in the migration corridors between two waters. The depth where wiggles occurred was 10-40 m in the California coast, whereas 30-100 m in the EEP. These areas match up well with area restricted search (ARS) behavior analyzed by horizontal movement (Benson et al. 2011). These results indicate that these areas were foraging hotspots for leatherback turtles in the eastern Pacific.

EXPLORING THE USE OF HYDROGEN ISOTOPES (d2H) AS A TOOL TO STUDY SEA TURTLE DIET AND HABITAT USE

Laura Pagès Barceló[1]

[1]*University of New Mexico*

Sea turtles have been severely impacted by numerous anthropogenic activities and yet we know little about their ecology because their elusive nature makes them difficult to study. Two aspects we still know little about are their resource and habitat preferences, and how these vary among individuals or among age classes. Carbon (d13C) and nitrogen (d15N) stable isotope analysis has proven to be a useful tool for sea turtle diet composition and habitat use. Here we compare d13C and d15N data with hydrogen isotopes (d2H) to determine if d2H can be used to characterize resource and habitat use in green sea turtles living along the Pacific coast of Baja California Sur, Mexico. We measured skin d13C, d15N and d2H values from 82 green sea turtles collected from two open ocean and three lagoon sites. Using a logistic regression model, we found that d2H values, in conjunction with d13C and d15N isotopes, can help differentiate sea turtle habitat into either open ocean or lagoon habitats; for this model the residual deviance for lack-of-fit was 0.99 with a classification threshold of 0.9, indicating a strong fit and high classification accuracy. Thus, our preliminary results show that d2H can be used in three-factor models to more accurately interpret sea turtle habitat use. Including d2H data may also help identify the use of different resources. We found that turtles collected from open ocean habitats have higher mean (±SD) d2H values (-34±19) than turtles from lagoons (-49±25). Furthermore, a significant positive correlation between d2H and d15N values suggests that this pattern may be driven by differences in trophic level between turtles found in open ocean and lagoon habitats, although differences in the d2H composition of primary producers in open ocean (phytoplankton) versus lagoon (macroalgae and mangroves) habitats may also contribute to this trend. Comparison of sea turtle isotope values with those of potential prey will help us differentiate between these possibilities. Our results suggest that the use of hydrogen stable isotope as a third variable may be a valuable tool for understanding sea turtle ecology in coastal settings.

LONG-TERM RESOURCE USE AND FORAGING SPECIALIZATION IN MALE LOGGERHEAD TURTLES*

Mariela Pajuelo[1], Karen A. Bjorndal[1], Michael D. Arendt[2], Allen M. Foley[3], Barbara A. Schroeder[4], Blair Witherington[5], Alan B. Bolten[1]

[1]*Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida, Gainesville, FL 32611, USA*
[2]*South Carolina Department of Natural Resources, Marine Resources Division, Charleston, SC 29412, USA*
[3]*Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Jacksonville Field Laboratory, Jacksonville, FL 32218, USA*
[4]*National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD 20910, USA*
[5]*Disney Animals, Science and Environment, Lake Buena Vista, FL 32830, USA*

Intra-population variation in resource use has been increasingly reported for different taxa. In particular, foraging specialization of individuals has been quantified for various generalist populations. Because individual differences in resource use can have a great effect on a population's

ecological and evolutionary dynamics, it is essential to accurately assess how individuals exploit resources. Recent studies have shown that female sea turtles exhibit long-term individual specialization in resource use. In this study, we used stable isotope analysis (d15N and d13C) of serially sampled sea turtle scutes from two foraging areas in the Northwest Atlantic to evaluate whether male loggerhead sea turtles (*Caretta caretta*) exhibit patterns in resource use over time similar to those reported for female turtles. We found that some male loggerheads show individual specialization and a long-term consistency in resource use over several years – which adds support to previous findings that male loggerheads exhibit site fidelity to their foraging areas – while others are less consistent or only exhibit consistency for shorter periods of time. This variation in patterns of resource use among male loggerheads appears to be linked to foraging area locations, which were characterized by distinct resource diversity. Thus, these results suggest that resource diversity (habitat and prey items) present at the foraging areas may affect the degree of temporal consistency in resource use and potentially individual foraging specialization in loggerheads. Understanding the drivers of intra-population variation in resource use in loggerheads will allow us to predict how they will respond to changing environmental conditions.

DETECTION AND USE OF SEASONALLY EPHEMERAL FISH-CLEANING STATIONS BY BREEDING SEA TURTLES USING DRONES AND UNDERWATER CAMERAS*

Kostas Papafitsoros[1], Rebecca Haughey[2], Kostas A. Katselidis[3], Gail Schofield[2]

[1]*Weierstrass Institute, Berlin, Germany*
[2]*Deakin University, Geelong, Australia*
[3]*National Marine Park of Zakynthos, Zakynthos, Greece*

The removal of parasites from the external body surface through cleaning enhances the health, fitness and survival of wildlife. Here, we used a combination of aerial (drones) and underwater (videos and stills) surveys (totalling 160 field hours) to evaluate how loggerhead sea turtles use seasonally ephemeral fish-cleaning stations (2x2.5m area) at a temperate breeding ground (Zakynthos, Greece, 100km2) across a 2-year period (2015–2016). The location of the fish cleaning stations changed across years, and were isolated rocks of about ~5m2 within 6km of submerged sandbanks in the 106km2 breeding area. Turtles began using the 2016 station from mid-May, which was when mating activity dropped off, with more turtles frequenting the station on south-type wind days (confirmed in both drone and underwater surveys). Turtles that used the station generally moved in the same direction as the wind (upwind to downwind). Fish primarily remained within a 5–7m radius of the station, with turtles having to enter this area to solicit cleaning. The species and size-class of cleaner-fish changed between years; in 2015, ~35–80 juveniles of ~3–5cm body-length from at least three Mullidae and Sparidae fish species cleaned turtles versus just ~25 juvenile sheepshead bream of ~12–15 cm body-length in 2016. Station use was highest in June compared to July in 2016, and clearly declined through July in both 2015 and 2016. During intensive (up to 5-h) daily surveys over 55-days in 2016, we photo-identified 55 unique individuals (including 2 males and 1 possible immature turtle), representing 11–18% of estimated reproductive females. We recorded new individuals throughout the survey period, of which only 27% returned 1–5 times at intervals of mean 11 ± 9 days for up to 37 days. Within a given survey, 75% of turtles visited the station once for mean 5 min bouts, while the remainder returned 2–7 times within a mean 63 min period (max: 205 min) for mean 10 min bouts, suggesting intentional use of the station. Drone surveys indicate that more turtles were present within 100m radius of the station than we detected during underwater surveys, suggesting protracted visitation throughout the day. In 41 instances, 2 or more turtles were present at the station, queueing (approaching the station but not the turtle being cleaned) or competing (approaching the turtle being cleaned, but not aggressively) for access to fish. When a turtle entered the station area where a turtle was already being

cleaned, some or all fish immediately switched turtles, but did not necessarily remain on the new client. On some occasions, the larger turtle was selected, but not consistently. In conclusion, our surveys indicate that some turtles intentionally locate fish cleaning stations each year and solicit cleaning activity following the completion of mating and until departure for foraging grounds, possibly to reduce epibiont loads, which might hinder subsequent migration back to foraging sites up to 1000km distant.

KEMPS RIDLEY SEA TURTLE HABITAT USE AND DIET VARIATION REVEALED THROUGH COMBINED TRACE ELEMENT AND STABLE ISOTOPE ANALYSES*

Matthew D. Ramirez[1], Jessica A. Miller[1], Larisa Avens[1], Selina S. Heppell[1]

[1]*Oregon State University, Corvallis, Oregon, USA*

An understanding of intrapopulation variation in resource use is fundamental to effective species conservation and management as it can have strong effects on population and community dynamics. Multiple biogeochemical analyses can be used to characterize long-term resource use in sea turtles, such as stable isotope analyses, which can be used to quantify trophic niche width and the degree of individual diet specializations within populations. Likewise, trace element analyses can be used to identify intrapopulation variation in the timing of habitat shifts. Here, we combine skeletochronology and multiple biogeochemical analyses of humerus bone tissue to characterize intrapopulation variation in resource use for Kemp's ridley sea turtles (*Lepidochelys kempii*) throughout their range. Humerus bones were collected through the Sea Turtle Stranding and Salvage Network (STSSN) from dead turtles stranded on U.S. beaches in the Gulf of Mexico (n = 24) and Northwest Atlantic Ocean (n = 21). Two bone cross-sections were cut from each humerus bone, with the first used for skeletochronology and the second used for complementary biogeochemical analyses. A high-resolution micromilling system was employed to collect bone dust from individual growth layers for stable isotope analysis (δ13C, δ15N). Laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS) was used to quantify elemental composition (86Sr/43Ca, 138Ba/43Ca) along transects perpendicular to growth layers. Growth increment-specific biogeochemical data were paired with body size, growth, and age information obtained from skeletochronology to examine relationships among covariates. Stable isotope and trace element data showed distinct patterns with age; mean values plateaued after either increasing (δ15N) or decreasing (86Sr/43Ca, 138Ba/43Ca) up until age two. Values at age two and older were significantly different from those at age zero (p less than 0.01, Mann-Whitney U test), whereas values at age one were intermediate. Mean δ13C values did not differ by age, and biogeochemical ratios did not differ between Gulf of Mexico and Northwest Atlantic Ocean stranded turtles. These results are consistent with current understanding of Kemp's ridley sea turtle life history, which presumes a shift from oceanic to neritic habitats and epipelagic to benthic prey by age two, and mirror patterns observed in loggerhead sea turtles in relation to a presumed oceanic-to-neritic habitat and diet shift. Despite the observation of a consistent increase and plateau in δ15N values with age among sampled turtles, considerable intrapopulation variation in δ15N values was observed at all ages, although values were temporally consistent within individuals after age two. These results align with previous stable isotope studies in loggerhead and green sea turtles, which showed that individuals of these species are often long-term diet specialists within a generalist population. The integration of skeletochronology and multiple biogeochemical analyses provides a valuable tool to understand intrapopulation variation of sea turtle life history.

UNDERSTANDING OFFSHORE CONGREGATIONS OF OLIVE RIDLEYS IN AN ARRIBADA POPULATION ALONG THE COAST OF ODISHA

Chetan Rao[1]

[1]*Dakshin Foundation*

The mass-nesting populations of olive ridley turtles in the mass nesting rookeries of Odisha have been well documented. The arribada is primarily observed at beaches in two parts of the state: one in the north (Gahirmatha) and one in the south (Rushikulya). Turtles begin to congregate in large numbers throughout the 480-km long Odisha coastline from early December and remain nearshore till the arribada in February/March. Although their nesting biology has been well studied, their offshore biology remains largely unknown. Offshore monitoring at Rushikulya began in 2010 to ascertain patterns in changing offshore abundances and factors that influence turtle congregations in multiple locations along the coast. This was initially carried out only at the mass nesting site of Rushikulya and later extended to cover the entire coastline of Odisha in January 2014 to cover 7 sites along the coast. All the locations were chosen next to river-mouths and had evidence of nesting turtles. A line transect approach was followed to locate turtles during the breeding season. Each transect block had 6 perpendicular (4 km) and 5 parallel boat transects (2 kms). The total distance of the transect block was 34 km. The transects were designed using stratified random sampling within each sampling block. Individual surfacing turtles and mating pairs were counted using double observers and their densities were estimated using Distance (Thomas et al 2010). Location data was collected using a handheld GPS. Along with observations of turtle numbers, abiotic factors were also sampled (surface salinity, surface temperature depth) to explore factors influencing these congregations. The transects were sampled once a month until the onset of the arribada. The surveys were carried out from December 2013 to March 2016. Our results show the formation of dense congregation patches around the mass nesting beach of Rushikulya during late January to March. There also seemed to be spatio-temporal variation in congregating numbers and the reproductive patches grew denser around Rushikulya from December to March. Maximum numbers of turtles were observed in Rushikulya in all seasons. The occurrence of turtles reduced in number in other survey sites from December to March. All congregations were 5-7 km from the coastline within a depth range of 20-30m. Information on the offshore distribution of turtles needs to be monitored to identify critical areas of turtle congregation thereby reducing the risk of bycatch from fishing during certain times of the year and aiding their conservation.

WHERE ARE THE AGGREGATION AREAS OF THE CRITICALLY ENDANGERED HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) IN PERU?

Carmen Rosa Gonzalez[1,2], Shaleyla Rosa Gonzalez Kelez[1]

[1]*ecOceanica*
[2]*University Scientific of the South*

In Peru, the hawksbill turtle is the most tropical of all sea turtles recorded and that is why it is found mainly on the northern coast (Tumbes and Piura), although it has been reported further south during El Niño events. Currently, in Peru, we are facing a great lack of information about which areas are being used by these turtles for foraging and development and if any nesting is occurring, perhaps in mangrove areas. Also, their shells are highly prized and its commercialization can still be seen in touristic places of northern Peru. The only available information on hawksbills in Peru comes from records of strandings, bycatch and shells used

ornamentally. In a sea turtle survey conducted in 1978, only 5 hawksbill shells of juvenile size were observed in the northernmost coast of Peru. In 2000, a survey conducted along 915 km of coastline found the presence of hawksbill to be rare; only one shell was observed and people interviewed were not familiar with this species. During a yearlong survey of sea turtle strandings in Tumbes, only one hawksbill was reported stranded. During a fisheries study in Tumbes from August 2007 to August 2009 only one specimen of *E. imbricata* was caught in fishermen nets. Another fisheries study from 2000 to 2009, reported 18 hawksbills as incidentally captured by fishers operating in 3 ports in Piura, these turtles were juveniles and were captured in gillnets. Eight hawksbill specimens< were recorded in Ica and Lima in another survey; all were juveniles and most of them were found as ornamental shells. In summary, what we know is that hawksbill are more frequent in northern Peru and almost all individuals recorded had been juveniles. Besides this and a current study that is tracking hawksbills that had been incidentally captured in Piura, there is no more information on this endangered species in Peru. Due to the scarce information on hawksbills in Peru, this study aim is to start filling some of the gaps beginning by locating their main aggregation areas in northern Peru. This information will contribute to their in-situ conservation. Our methodology involves conducting interviews along the coast of Tumbes and northern Piura as well as conducting field surveys. Also, at each site visited, informal meetings with fishermen and villagers will be held to share knowledge and raise awareness on the hawksbill turtle and its critical situation. This is an ongoing study that will be conducted until the austral summer of 2016-2017 and the main results will be presented at the Symposium. So far, our preliminary results are the following: interviews conducted in the National Sanctuary Los Manglares de Tumbes show that 22% of fishermen are familiar with hawksbills in the area, field surveys recorded individuals from 35.2 to 61.5 cm of CCLnt with an average of 44.3 cm (n=9), hawksbills have been observed inhabiting waters of El Ãuro and Punta Veleros in Piura and Puerto Pizarro in Tumbes.

SEA TURTLE DISTRIBUTION AND HABITAT SELECTION IN THE GULF OF MEXICO FOLLOWING THE DEEP WATER HORIZON OIL SPILL*

Alexander E. Sacco[1,2], Nathan F. Putman[3], Lance P. Garrison[4], Erin E. Seney[1], Katherine L. Mansfield[1]

[1]UCF Marine Turtle Research Group Department of Biology University of Central Florida Orlando FL 32826 USA
[2]Cooperative Institute for Marine and Atmospheric Studies Rosenstiel School of Marine and Atmospheric Science University of Miami Miami FL 33149 USA
[3]Atlantic Oceanographic and Meteorological Laboratory National Oceanic and Atmospheric Administration Miami FL 33149 USA
[4]Southeast Fisheries Science Center National Marine Fisheries Service Miami FL 33149 USA

Five species of sea turtles spend at least part of their life in the Gulf of Mexico: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles. The 2010 Deepwater Horizon oil blowout affected marine life in the Gulf of Mexico, including all sea turtle life history stages. A major challenge during and after the oil spill was estimating the areas of highest impact on marine turtles, primarily due to the lack of data on abundance and habitat preferences in marine ecosystems. We analyzed aerial survey data collected during spring (April – May), summer (July – September), and fall (October – December) 2011, and winter (January – March) 2012 to estimate the abundance and density of four species of sea turtles (Kemp's ridley, leatherback, loggerhead, green; SCL > 40 cm) over the continental shelf in the Gulf of Mexico. One plane with two independent observer teams (front and back) was used to collect turtle observations. The estimated detection probabilities for turtles at the surface typically range from 30 – 50% for all seasons

surveyed (spring, summer, fall, winter) and turtle abundance estimates indicate significant seasonal variation. Fitted generalized additive models were used to predict probabilities of density for all turtles observed during the non-nesting and nesting seasons. Environmental predictors included the General Bathymetric Chart of the Oceans (GEBCO) 2014 30-sec gridded bathymetry maps and daily modeled oceanographic outputs from the Hybrid Coordinate Ocean Model (mixed-layer depth, salinity, sea surface height, sea surface temperature, and ocean current vectors) centered on turtle observations. Modeled surficial sea turtle distribution and habitat selection exhibited species-specific and seasonal variation throughout the Gulf of Mexico, delineated mainly by sea-surface temperature, mixed-layer depth, ocean salinity, and bathymetry. These data will aid research on post-oil spill sea turtle distribution variance, help assess future anthropogenic impacts, inform ecosystem models for the Gulf of Mexico and elsewhere, as well as provide baseline data for sea turtle distributions in the Gulf of Mexico.

FORAGING ECOLOGY OF GREEN TURTLES (*CHELONIA MYDAS*) IN SOUTHERN CALIFORNIA IN AREAS UNDER DIFFERENT LEVELS OF HABITAT ALTERATION: INSIGHTS FROM STABLE ISOTOPE ANALYSIS

Joel Schumacher[1]

[1]*NOAA – SWFSC*

Foraging ecology of green turtles (*Chelonia mydas*) in southern California in areas under different levels of habitat alteration: insights from stable isotope analysis Habitat restoration has become an increasingly important in combating extinction of threatened species. However, habitat restoration is case specific, and the extent of the initial alteration and subsequent restoration can vary widely between sites. Urbanized environments often contain a mosaic of varying levels of impact, and a highly altered site may sit next to sites under varying guises of "restored" status. It is key to understand how these habitat dynamics affect the ecology of endangered species that inhabit these areas. We used stable isotopes to examine the foraging ecology of three distinct foraging populations of green sea turtles (*Chelonia mydas*) in southern California, USA, each at a location with a unique restoration history: 1) San Diego Bay, a recently restored urbanized shallow bay 2) San Gabriel River, a highly altered estuary system, and 3) Seal Beach Wildlife Refuge, a partially restored wetland. Stable Isotopes of San Diego Bay were also compared with pre-restoration values. These are the first post-restoration results for San Diego Bay and the first reported results for the other two locations. Mean δ15N values were 18.54±1.3 ‰, 16.54±1.3 ‰, and 16.93±0.8‰ for San Diego Bay, San Gabriel River, and Seal Beach Wildlife Refuge, respectively. Mean δ13C values were -15.88±1.4‰, -16.95±2.3‰, and -15.04±1.4‰ for San Diego Bay, San Gabriel River, and Seal Beach Wildlife Refuge, respectively. San Diego Bay δ15N values were significantly higher than the San Gabriel and Seal Beach, but were not significantly different from samples collected pre-restoration at San Diego Bay, indicating foraging differences in this population that have remained constant throughout the restoration process. δ13C values were not significantly different among locations. These results show how isotopic trends can differ among similar habitats affected by varying levels of anthropogenic alteration, and highlight the need for comparative studies that delve into ecological differences caused by urbanization.

SHIFTING DIETS OF LOGGERHEAD AND KEMP'S RIDLEY SEA TURTLES IN VIRGINIA, USA

Erin E. Seney[1], Shannon J. Reinheimer[2], Ashley L. Bankowski[3], LaCheryl A. Ball[4], Sarah D. Mallette[2], Susan G. Barco[2]

[1]*University of Central Florida, Orlando, Florida, USA*
[2]*Virginia Aquarium & Marine Science Center, Virginia Beach, Virginia, USA*
[3]*Birdneck Animal Hospital, Virginia Beach, Virginia, USA*
[4]*Virginia-Maryland Regional College of Veterinary Medicine, Blacksburg, Virginia, USA*

The Chesapeake Bay and Atlantic Ocean waters of Virginia, USA are seasonal developmental and migratory areas for loggerhead (*Caretta caretta*) and Kemp's ridley sea turtles (*Lepidochelys kempii*). Diet characterization provides a window to these carnivorous species' habitat needs, ecosystem roles, and potential anthropogenic threats. The occurrence of dietary shifts makes continued examination of Virginia's sea turtle diets valuable to ongoing conservation efforts. Loggerheads' primary prey in Virginia shifted from horseshoe crab (*Limulus polyphemus*) to blue crab (*Callinectes sapidus*) to bony fishes and hermit crabs (*Pagurus* spp.) during 1983-2002 (Seney and Musick 2007), whereas ridleys have historically shown preferences for decapod crustaceans (Seney and Musick 2005). During 2010-2013, gastrointestinal (GI) tract samples were collected from dead stranded loggerheads and Kemp's ridleys by the Virginia Aquarium and partners. Contents were subsequently sieved, sorted, and identified, with estimated prey counts and dry weights recorded for whole (esophagus to colon) samples. Diet was characterized using percent occurrence and percent index of relative importance (%IRI), a compound index combining frequency, count, and weight data. Schoener's Index was used to estimate interspecific diet overlap using prey weights. One-hundred and twenty-five loggerhead (2010-2012) and 81 Kemp's ridley (2010-2013) GI samples were examined. About two-thirds originated from turtles stranding along the Chesapeake Bay, with the rest from Virginia's Atlantic coast. Sampled loggerheads averaged 75.0 cm straight carapace length (SD=14.0 cm), and ridleys averaged 38.3 cm (SD=9.9 cm). Eighty-five percent of both species consumed decapod crustaceans, and 50% of loggerhead and 25% of ridley samples contained horseshoe crabs. Bony fishes occurred in approximately a quarter of both species' samples. The top five %IRI values for whole loggerhead samples (n=71) were for horseshoe crab, large whelks (Busyconidae), blue crabs, bony fishes, and spider crabs (Libinia spp.), as compared to blue crabs, mud snails, spider crabs, bony fishes, and hermit crabs for Kemp's ridleys (n=42). Interspecific diet overlap was approximately 53%. Compared to historical data, Virginia's loggerheads appear to have shifted back toward more natural prey items during 2010-2012, but bony fishes were still a substantial diet component, particularly for smaller turtles and in the Chesapeake Bay. Larger, Atlantic coast strandings comprised a greater proportion of the 2010-2012 dataset, and these loggerheads appeared more likely to consume horseshoe crab and whelks. Primary components of 2010-2013 Kemp's ridley diet were similar to historical results, with several notable exceptions: decapod crustacean consumption and species diversity decreased, and bony fish and horseshoe crab consumption increased. Despite differences in prey species composition, the level of interspecific diet overlap was similar to that in 2001-2002 (46%, Seney and Musick 2005). Increased consumption of horseshoe crab by both turtle species may be indicative of an increased prey population. Continued fish consumption is of concern, given its probable connection to feeding in nets or on discarded bycatch or bait. Dietary information should continue to be utilized to complement stranding examinations and population assessments and to inform conservation decisions for these long-lived, protected species.

DOES THE SAME NESTING TURTLE USE THE SAME MIGRATORY STRATEGIES IN DIFFERENT NESTING YEARS?

Chia-Hsiang Su[1], I-Jiunn Cheng[1]

[1]Institute of Marine Biology, National Taiwan Ocean University

Except for nesting events, most sea turtles spend more than 95% of their lifetime submerged, and are difficult to observe directly. The satellite telemetry enables us to determine their behavior in the sea. Previous studies have categorized their diving behaviors into different types with specific activities (e.g., resting, exploring and traveling). Even though the inter-nesting behavior of green turtles in Taiwan has been studied extensively, little is known about their diving behavior during the post-nesting and foraging phases. Two satellite transmitters (SRDL) were deployed on the same green turtle (tag no. TW139) nested in Wan-an Island, Peng-Hu Archipelago in 2013 and 2015. Results showed that in these two years, the turtle mainly distributed in the nearshore waters of Wan-an and Jiangjyun islands during the inter-nesting period. The turtle migrated southwest during the post-nesting phase in both years and reached its foraging ground; Dongsha atoll. Diving data showed that, during the post-nesting phase the turtle mainly used shallow or S-types. However, the same turtle adopted different migratory strategies in different years. In one year, turtles used shallow diving during daytime and switched to S-type diving patterns during the night. In the other year, turtles used an S-type diving pattern in both day and night. It is suggested that the distinct different migratory strategies might be related to the different environment it encountered during the post-nesting migration. This in terms affects their travel speed. Therefore, it is proposed that even the same nesting turtle can change their migratory strategies in order to adapt to a different environment.

DIVE BEHAVIOR DURING POST-NESTING MIGRATION OF LOGGERHEAD TURTLES NESTING AT THE SOUTHERN PART OF JAPAN.

Kaede Tomidokoro[1], Junichi Okuyama[1], Mamiko Arita[1], Yasushi Mitsunaga[1]

[1]Kindai University, Faculty of Agriculture, Fishery Department, Research Center for Subtropical Fisheries Seikai National Fisheries Research Institute

Loggerhead turtles after nesting are known to exhibit a size-related migration (foraging) dichotomy; smaller females migrate to oceanic areas in the north Pacific, whereas larger females to the neritic waters in the East China Sea. However, little is known about how turtles forage and behave in each foraging habitat, although Hatase et al. (2007) reported the dive behavior of a single female in each habitat. This study investigates dive behavior during post-nesting migration of loggerhead turtles nesting at Okinoerabu Island which is located on the southern part of Japan. We deployed a satellite-relay data logger (SMRU instrumentation) on four females after nesting. They were tracked for 59 and >153 days (still tracked). The largest female migrated into the neritic East China Sea after the nesting season, whereas the 2nd largest female moved into the coastal area of the mainland of Japan. Meanwhile, the other smaller females migrated on the way of Kuroshio Current and Kuroshio Extension Current, and then to oceanic areas in the North Pacific. The dive depth of the largest female staying in the neritic area of the East China Sea was 20-30 m in a night, while <10 m in a day. This diel change in dive performance was different from a previous study reporting that a large female spent most of the time at 100-150 m of depth during the day and at 0–25m depths during the night (Hatase et al. 2007). Shallow dives observed in this study were likely to be because of bathymetric conditions in the East China Sea. The second largest female staying in the coastal

area of Japan mainland also showed a different diel rhythm that she dived to deeper waters (around 60 m) in the daytime, while to shallower waters (<10 m) in the nighttime. Two smaller females migrating to the oceanic area dove to 30-60 m in depth during the night, while to shallow waters (<10 m) in the daytime. These dive performances observed in this study were also different from the previous study (Hatase et al. 2007) showing that oceanic females dove to relatively shallower waters (0-25 m) both in a day and night. Therefore, foraging and resting behavior of post-nesting loggerhead females both in neritic and oceanic habitats may change with environmental and geographical conditions.

APPLICATIONS FOR STUDYING FINE-SCALE BEHAVIORS OF MARINE TURTLES IN RESPONSE TO SOUND

Reny B Tyson[1], Wendy E. D. Piniak[2], Camila Domit[3], David Mann[4], Douglas P. Nowacek[5], Mariana M. P. B. Fuentes[6]

[1]Chicago Zoological Society's Sarasota Dolphin Research Program
[2]Department of Environmental Studies at Gettysburg College
[3]Laboratório de Ecologia e Conservação Centro de Estudos do Mar Universidade Federal do Paraná
[4]Loggerhead Instruments Inc.
[5]Nicholas School of the Environment & Pratt School of Engineering at Duke University Marine Laboratory
[6]Department of Earth Ocean and Atmospheric Science at the Florida State University

Increases in the spatial scale and intensity of activities that produce marine anthropogenic sound highlight the importance of understanding the impacts of sound on threatened and endangered species such as marine turtles. Marine turtles detect and behaviorally respond to low-frequency sounds, however very few studies have directly tested their behavioral responses to specific types or intensities of anthropogenic sounds. Of the few studies conducted, nearly all focused on marine turtle responses to seismic airguns and were conducted in enclosed settings, limiting the ability to assess potential behavioral responses of freely swimming marine turtles to anthropogenic and natural sound sources. Recent advances in the development of bio-logging tools that combine acoustic and fine-scale movement measurements have been used to successfully quantify behaviors in marine organisms such as marine mammals, including insights into an animal's response to sound. We describe these tools and present a case study demonstrating the potential application of a newly developed technology (RO-TAG, Loggerhead Instruments, Inc.) to examine behavioral responses of freely swimming marine turtles to sound. The RO-TAG incorporates a 3-axis accelerometer, gyroscope, and magnetometer to record the turtle's pitch, roll, and heading, a pressure sensor to record turtle depth, a hydrophone to record the turtle's received underwater acoustic sound field, a temperature gauge, and two VHF radio telemetry transmitters and antennas to allow for tag and turtle tracking. Tags can be programmed to automatically release via a timed corrodible link from a plastic plate affixed to a turtle's carapace with epoxy several hours or days after deployment. We present an example of the data collected with these tags by describing a case study of a successful RO-TAG deployment on a juvenile green marine turtle (Chelonia mydas) in the Paranaguá Estuary Complex, Brazil. The tag was deployed on the turtle on 26 May 2016 for 3.69 hours, during which several vessels passed close (less than 2 km) by the turtle. The concurrent movement and acoustic data collected by the RO-TAG were examined during these times to determine if the turtle responded to these anthropogenic sound sources. While fine-scale behavioral responses were not apparent (second-by-second), the turtle did appear to perform dives during which it remained still on or near the sea floor during several of the vessel passes. More records of vessels near tagged turtles and their approximate distances are needed to fully investigate whether turtles, such as the one presented here, respond to sounds produced by such anthropogenic sources; however this case study provides proof-of-concept that RO-TAGs can successfully be applied to free-ranging marine turtles for this purpose. Finally, we discuss the broad applications these tools have for studying the fine-

scale behaviors of marine turtles in response to sound and highlight how they can be used to aid in marine turtle conservation and management.

INTERACTION BETWEEN GREEN TURTLES AND THE INVASIVE SEAGRASS *HALOPHILA STIPULACEA* IN THE SOUTHERN CARIBBEAN*

Elizabeth R. Whitman[1], Laura García Barcia[1,2], Nikki Brito[1], Caroline Rinaldi[3], Michael Heithaus[1], Damien Chevallier[4], Jeremy Kiszka[1]

[1]*Florida International University*
[2]*Autonomous University of Barcelona*
[3]*Association Evasion Tropicale*
[4]*Institut Pluridisciplinaire Hubert Curien*

The extent to which an invasive species affects ecosystem dynamics greatly depends on its ability to out-compete native species. Particularly successful marine invasive species can have detrimental effects on coastal ecosystems and local fisheries-based economies. Following the Enemy Release Hypothesis, invasive species succeed because they are no longer controlled by their natural enemies. If local grazer populations preferentially feed on native species, they can facilitate invasions, while preferential herbivory on an invader may minimize its impact. Halophila stipulacea, a seagrass native to the Indian Ocean, has successfully spread to the Mediterranean and southern Caribbean. Likely transported by pleasure yachts, *H. stipulacea* is fast-growing, a high-volume seed producer, and has the ability to tolerate a wide range of salinities, temperatures, depths, and disturbance regimes. With the very recent invasion of *H. stipulacea* into the Caribbean, we do not yet know the impact it will have on local ecosystems and the effects of grazing on the invasion. Our study is aimed at elucidating the role grazers – particularly green turtles – can play in mediating the effects of the spread of *H. stipulacea*. To do so, we investigated the foraging behavior of grazing green turtles in a small seagrass dominated bay located on the west coast of Guadeloupe (French West Indies), in the southern Caribbean. Through individual video focal follows, using a GoPro® mounted on a 2 m extendable pole, we identified feeding preferences of green turtles in relation to seagrass composition to identify individual and population level grazing preferences. We conducted more than 100 focal follows on more than 70 individual animals between the spring of 2015 and fall of 2016. For this analysis we include only videos in which we could assess the broad seagrass composition and infer foraging habitat preferences. In total, 70 focal followers were used in the analysis, equaling approximately 27 hours of cumulated follow ($\mu \approx 20$ min/follow) of video. Preliminary results reveal fewer than 30% of individuals foraging on *H. stipulacea* with no apparent trends in preference by animal size or location. Conversely, green turtles showed a clear preference for native seagrass species, particularly *Syringodium filiforme*. Our data highlight the importance of behavioral observations in the assessment of green turtle feeding preferences in the context of the invasion by *H. stipulacea*. This study provides the first insight into the feeding ecology of green turtles in the Lesser Antilles, and our results are critical to improving our understanding of the ecological roles and importance of megaherbivores, in the context of the spread of an alien seagrass species.

OCEANIC OVERWINTERING IN JUVENILE GREEN TURTLES (*CHELONIA MYDAS*)*

Amanda S. Williard[1], April Goodman Hall[2], Ikuko Fujisaki[3], Joanne Braun McNeill[2]

[1]*University of North Carolina Wilmington*
[2]*NOAA Beaufort Laboratory*
[3]*University of Florida*

Green turtles (*Chelonia mydas*) spend the first several years of life in oceanic nursery habitats before recruiting to coastal developmental habitats as juveniles. Traditional green turtle life history models assume that the ontogenetic habitat shift is permanent and associated with a transition from omnivory to herbivory, and that seasonal movements between temperate foraging sites to thermally appropriate overwintering sites occur within the neritic zone. We deployed satellite transmitters on juvenile green turtles captured at a temperate latitude foraging site to document seasonal movement patterns and identify overwintering strategies. We found that the majority (73%) of juvenile green turtles left the neritic zone and exploited oceanic habitats during the late fall or winter. While previous studies have indicated that juvenile green turtles may spend time in deep (>200 m) waters near the continental shelf break during the winter, ours is the first to report long-distance migratory movements, and presumably foraging, in the open ocean. Our findings contradict the widely held notion that juvenile green turtles adopt a strictly herbivorous, benthic foraging pattern after recruitment to the neritic zone, and illustrate that there is plasticity in the ontogenetic habitat shift. These results have important implications for understanding somatic growth and population dynamics for this endangered species.

Nesting Biology

FREQUENCY OF OCCURRENCE, FORAGING AREAS AND REPRODUCTIVE HISTORIES OF LOGGERHEAD TURTLES THAT NESTED ON SUCCESSIVE YEARS ON KEEWAYDIN ISLAND, FLORIDA, U.S.A.*

David Addison[1], Katherine L. Mansfield[2], Katrina Phillips[2]

[1]*Conservancy of Southwest Florida*
[2]*University of Central Florida*

Loggerhead turtles (*Caretta caretta*) typically nest at 2-4 year intervals. Saturation tagging during long-term nightly surveys of nesting beaches periodically document females that nest on consecutive reproductive seasons. Over the 32 summers these repeatable surveys have been conducted on the southern 7.4 km of Keewaydin Island, 14 loggerhead turtles have been documented as having nested over sequential seasons. Twelve nested for two consecutive years, one nested over three sequential nesting seasons and another for seven successive seasons. Collectively, they comprised .8% of all the 2,012 one-time and inter-annual nesting turtles we have observed on Keewaydin, and for which we have tagging data. Of this total, 458 returned to nest over multiple seasons. These 14 turtles accounted for 3.1% of this this total. Of the total of 4,725 nests we've documented, this group accounted for 101 nests. The mean clutch size was 92 eggs as opposed to the mean of 102 eggs for all nests. Their nests resulted in 8,105 hatchlings reaching the Gulf of Mexico; 3.1% of all hatchlings documented. Three of the sequential nesters happened to be satellite tagged. Two of them nested over two consecutive seasons while the other has returned annually for seven successive seasons; most recently in 2016. The location of the foraging areas established by these loggerheads proved not to be notably closer to the Keewaydin nesting beach than the foraging areas established by nine other satellite tagged turtles that nested over discontinuous years. The story the data on these sequential nesting loggerheads tells indicate that such events occur infrequently and seem to be random. With a few exceptions, they take place most often over two reproductive seasons with the distance from the nesting beach to the foraging grounds fairly consistent with that of turtles that nest over discontinuous years. While 2–4-year nesting intervals for loggerheads are the rule, this unusual variability in the reproductive cycle may at times have survival value over the long term.

HAWKSBILL (*ERETMOCHELYS IMBRICATA*) UNIQUE NESTING BEHAVIOR IN ESTERO PADRE RAMOS AND ASERRADORES*

Eduardo Altamirano[1], Velkiss Gadea[1], Jose Urteaga[2], Alexander Gaos[3], Perla Torres[4], Michael J. Liles[3], Luis Manzanares[1], Ingrid L. Yañez[3]

[1]*FFI*
[2]*Stanford University*
[3]*ICAPO*
[4]*Universidad Nacional Autonoma de México*

On the Northwest Coast of Nicaragua, the dense mangrove estuaries and the dry vegetation of the beach forests represent ideal nesting sites for the Eastern Pacific Hawksbill Turtle. Where the structure of the ecosystem is practically the same. But it differs only from the magnitude of the anthropogenic impact. In Estero Padre Ramos managed by a collaborative management committee there is more anthropogenic

influence due to five communities that are distributed around the nesting zone, while in Aserradores it is managed by a single owner and the use of natural resources is minor. Fauna & Flora International (FFI) and the Eastern Pacific Carey Initiative (ICAPO) have led the development of hawksbill conservation projects at both sites, starting in 2010 at Padre Ramos and 2013 at Sawmills. The data have been collected by a rigorous monitoring protocol that includes a monitoring process of nocturnal patrols that involves several activities such as: measuring and marking of nesting females (Pit and Inconel) and registering the nesting environment at the exact moment when You see the turtle. In addition, the protocol includes the establishment of hatcheries that study sand and nest temperatures and morphometric studies of neonates. Accompanied with a rigorous control of each nest. These hatcheries are managed by local community members with the help of international and national volunteers also interns from the National Universities. Nicaragua has more than 50% of hawksbill nesting sites in the Eastern Pacific and this is concentrated in Padre Ramos 47.6% and Aserradores 24%. (Gaos 2016). Since conservation efforts have been made in Aserradores, nesting data of females at different sites in the same season have been recorded, as well as females with the highest egg postures ≥ 270 and with a minimum of 5 eggs We report interesting reports on the nesting behavior of females since 2010 in Estero Padre Ramos and since 2014 in Aserradores. This has given valuable data to study and understand this particular population, which differs from others in their preference for nesting in a defined vegetation with a specific dynamics and also their migration between two estuaries, as well as the analysis of the viability of nests in hatcheries versus in situ, responding to the possibility of recovery of this species if nest were in situ. There are other sites that have not yet been studied in the same way as Padre Ramos and Aserradores, but indicate that there are more nesting sites such as Los Clavos and Estero Maderas Negras. It is believed that many of the turtle that have not been seen after being tagged, nest in those areas that have not yet been monitored. Because we have compiled information that there are nest and false crawls in those areas during the nesting season. This demonstrates that conservation efforts must be directed beyond a single estuary and strategies need to be interconnected. Therefore, this study is a first step to delve into the behavioral relationship of sea turtles to the ways in which the ecosystem is composed where they nest.

IMPACT OF SARGASSUM INFLUX DURING 2015 SUMMER ON MARINE TURTLES OF PLAYA LA BARCA, PENINSULA DE GUANAHACABIBES

Julia Azanza-Ricardo[1], René Pérez Martín[2], Fernando Bretos[3]

[1]Instituto Superior de Tecnologia y Ciencias Aplicadas
[2]Instituto Nacional de Higiene, EpidemiologÃ-a y MicrobiologÃ-a
[3]Patricia and Phillip Frost Museum of Science

In the last decade an increase in the accumulation of Sargassum has been reported throughout the Caribbean region. In 2015 these influxes caused serious impacts to marine turtles nesting and feeding areas, including Guanahacabibes Peninsula. This paper will focus on documenting all of the impacts caused by the influx of Sargassum fluitans in nesting beaches of marine turtles in Guanahacabibes Pensinsula, located on the westernmost tip of Cuba. To do so, photographic evidence about Sargassum distribution at the beach and the magnitud was gathered. At the same time nesting processes and hatching success were monitored. As a result, we found that loggerhead females were more affected than greens when they moved through the sargassum. In general, there was a desplacement of nesting activity almost exclusively to the sector of the beach between transects 12 and 15. Hatchlings were less affected since they began to hatch after the sargassum influx began to decrease. However, they had still had difficulties navegating the sargassum on their way to the open ocean. It is important to follow the trajectory and abundance of the sargassum masses to prevent future impacts on the coastal zone, especially, on marine turtle nesting areas and prevent it becoming a serious threat to nesting females and their hatchlings.

MONITORING OF LOGGERHEAD TURTLE POPULATION ON DALAMAN-SARIGERME AND FETHIYE BEACHES IN 2016, TURKEY

Musa Azmaz[1], Eyup Başkale[1], Yusuf Katılmış[1], Doğan Sözbilen[1], Yakup Kaska[1]

[1]*Pamukkale University, Turkey*

Breeding and nesting activities of loggerhead turtles on Dalaman-Sarıgerme and Fethiye beaches, that are located 40 km apart from each other, were studied in the 2016 nesting season. Monitoring of population studies have been carried out on these beaches for a long period of time. Due to the influence of anthropogenic factors on both beaches, coastal development increased in recent years. The nests were caged against predation and human activities. For Dalaman-Sarıgerme beach, a total of 175 emergences were recorded in 2016, of which 85 (48.5%) nests were determined and the remaining 90 (51.5%) were recorded as non-nesting emergences. On Fethiye beach, 218 loggerhead turtle emergencies occurred, and 112 (51.37 %) of these recorded as nests and the remaining 106 (48.63 %) were recorded as non-nesting emergences. Moreover, hatching was observed in 48 (56.5%) nests and 37 (43.5%) nests were predated by foxes in Dalaman-Sarıgerme while a total of 97 (86.6%) nests in Fethiye produced hatchlings and 15 (13.4%) nests were predated by foxes. After excavating the nests in both beaches, 6.437 eggs in Dalaman-Sarıgerme and 8.340 eggs in Fethiye were recorded. Hatching success was calculated as 49.6% with 3.194 empty eggshells that produced hatchlings in Dalaman-Sarıgerme, the hatching success of Fethiye was 69.2% with 5.771 empty eggshells. There are many anthropogenic factors negatively affecting the loggerhead populations on both beaches but the fox predation seems the most negatively recorded factor on both beaches, screening of nests against fox predation should be carried out in order to increase the hatching success.

WHAT INCUBATION PERIOD AND EMERGENCE ASYNCHRONY SAY TO US?

Eyup Başkale[1], Yusuf Katılmış[1], Musa Azmaz[1], Doğan Sözbilen[1], Yakup Kaska[1]

[1]*Pamukkale University*

Incubation period of sea turtles has affected by several factors such as temperatures of incubation, nesting zone characters, climates and nesting dates. These factors are strongly related each other. Furthermore, these factors can influence either biological aspects of sea turtle egg as size, mass, and amount of yolk content converted to hatchling tissue and hatchling sex or duration of incubation period, duration of hatchling emergence period and hatching success. In this respect, we investigate total 233 nests to determine incubation periods and emergences from the nests and hatching success due to temporal variations. According to our results, incubation periods were 74.8±4.79 days (n=4; range from 69 to 80) for nesting date of on April, 56.7±5.02 days (n=41; range from 48 to 70) for nesting date on May, 48.9±3.01 days (n=156; range from 41 to 54) for nesting date on June, 46.3±1.73 days (n=36; range from 41 to 51) for nesting date on July, 50.1±1.90 days (n=9; range from 48 to 54) for nesting date on August. Durations of hatchling emergence were found as 7.3±2.50 days (n=4; range from 4 to 10) for nesting date of on April, 5.8±1.90 days (n=41; range from 4 to 10) for nesting date on May, 5.3±1.50 days (n=156; range from 4 to 10) for nesting date on June, 6±2.14 days (n=36; range from 4 to 10) for nesting date on July, 8.1±0.93 days (n=9; range from 6 to 9) for nesting date on August. On the other hand, hatching success were calculated as 41.3±12.89, 88.8±14.50, 87.2±17.93, 91.4±9.50 and 86.0±24.39 respectively. We also found statistically significant differences incubation periods ($F=113.487$; $df=4$; $P<0.001$), durations of hatchling emergence ($F=8.380$; $df=4$; $P<0.001$) and hatching success ($F=8.292$; $df=4$; $P<0.001$) depend on months. The obtained

data showed that there is a statistically significant relationship between nesting dates and incubation periods (Pearson's correlations: r2= 0.86; p<0.001) while hatching success was not related to incubation durations (p<0.05). In addition to these, hatchling emergences from nests estimated as 6±1.78 days (range from 4 to 10days), and 62% of hatchlings emerged from the nests in the first two days. Our results showed that there are moderate relationships between incubation period and duration of hatchling emergence from the nests. As a conclusion, nests that their incubation periods coincide with the middle of the nesting season (such as June and July) has shorter incubation period and durations of hatchling emergence than beginning and ending of the nesting season (such as April, May and August).

A DECADE OF TAGGING SOLITARY NESTING OLIVE RIDLEYS IN COSTA RICA REVEALS A CONDITIONALNESTING STRATEGY*

Madeleine Beange[1], Randall Arauz[1]

[1]Centro Rescate de Especies Marinas Amenazadas (CREMA), Tibas, San Jose, Costa Rica

Olive ridleys (*Lepidochelys olivacea*) are unique in that they exhibit two reproductive behaviours: solitary and arribada (mass synchronous) nesting. Past research on Costa Rica's Pacific ridley population, focusing on the two established arribada beaches Nancite and Ostional, have suggested that the majority of turtles nesting in arribadas are loyal to this behaviour. However, an overall understanding of the population's nesting ecology isn't possible without researching Costa Rica's extensive solitary nesting beaches and recently identified young arribada beaches. To investigate how olive ridleys utilize the solitary nesting behaviour, we conducted tagging programs during the nesting season at the following beaches: San Miguel (2006-2016), Caletas (2006-2015), Corozalito (2008-2016), Costa de Oro (2012-2016), and Bejuco (2016). Corozalito is a young arribada beach, whereas the other four are strictly solitary nesting beaches. During nightly patrols solitary nesting turtles were tagged with inconel metal flipper tags on both foreflippers, and carefully checked for previous tags. In addition, tag checks were conducted during the six 2014 and 2016 Corozalito arribadas. Over the decade a total of 6450 turtles were tagged and 485 (7.6%) recaptures were recorded. In addition, 65 turtles were encountered that had been tagged while nesting solitarily at projects as far north as La Flor, Nicaragua and south as Corcovado, Costa Rica. Although the majority of the recaptured turtles were found nesting solitarily (440, 80%), a surprising number switched to nesting in arribadas (110, 20%). The majority of the ridleys that maintained the solitary behaviour had high nest-site fidelity (88% within 5 km, n=420), whereas those that switched to arribadas were found further away from their original tag site (58% > 5 km and 33% > 50 km, n=101). Also, there was a shorter internesting period for the solitary recaptures (23 days, n=334) than the arribada recaptures (31 days, n=81). The results of this study demonstrate that olive ridleys exhibit a conditional reproductive strategy, and reveal an important connection between Costa Rica's arribada and solitary nesting beaches. Interestingly, ridleys appear to nest within closer distances when employing the solitarily behavior, but migrate further to participate in arribadas. Future studies should focus on the environmental and physiological conditions governing this complex nesting strategy.

COROZALITO REVEALS HOW A CONDITIONAL NESTING STRATEGY CONTRIBUTES TO THE DEVELOPMENT OF AN ARRIBADA BEACH

Madeleine Beange[1], Alberto Queiruga[1], Annie Clift[1], Monserrat Lopez[2]

[1]Centro Rescate de Especies Marinas Amenazadas (CREMA). Tibas, San Jose, Costa Rica
[2]Turtle Trax S.A. Tibas, San Jose, Costa Rica

Corozalito, a beach on Costa Rica's Southern Nicoya Peninsula, is a recently identified olive ridley (*Lepidochelys olivacea*) arribada nesting beach. Since Corozalito's first mass-nesting event was reported in 2007, the arribadas have gradually increased in size and frequency. As a beach with this type of evolving nesting dynamic has not been previously documented, Corozalito offers a valuable opportunity to shed light on the complex reproductive strategy of olive ridleys. This study reviews the results obtained from the 2016-17 nesting season of the long-term monitoring project at Corozalito. Nightly patrols and morning censuses were conducted to record all solitary nesting events, and an instantaneous survey count method was used to estimate the number of nests laid during arribada events. Approximately four solitary nesting turtles were tagged per night with inconel metal tags on both foreflippers. In addition, a new saturation tagging approach was conducted in Corozalito during the first arribada event of the season. Two arribadas and 2400 solitary nesting events were recorded at Corozalito between July 1st and February 15th. The arribadas occurred 45 days apart, with the November event having an estimated 6,000 nests and October 10,000 nests. Recapture rates for this season were unusually high; 15% of the 349 tagged solitary nesters and 11% of the 280 tagged arribada nesters were reencountered. In addition, 10 turtles remigrated from previous seasons of nesting at Corozalito and 29 turtles were encountered that had been tagged at 11 other beaches. These beaches included Nancite (140 km NW), Quepos (155 km SE), Playa Tortuga (220 km SE), and Rio Oro (285 km SE), from which tagged ridleys hadn't been previously recovered at Corozalito. Solitarily tagged turtles exhibited a remarkable amount of behavioral plasticity, with about half of the 85 recaptures observed displaying each of the tactics. In contrast, all but two of the 27 recaptured turtles tagged in Corozalito, Rio Oro, and Nancite arribadas were re-observed using the same behavior. Despite the lack of arribada activity in 2015, this year's two large events indicate that Corozalito continues to grow as an arribada nesting beach. The tag results from this study indicate that two factors could be contributing to Corozalito's changing nesting dynamics. First, solitary nesters from both Corozalito and other beaches along Costa Rica's Pacific coast appear to be switching from solitary nesting activity to participate in the arribadas. Second, a group of faithful arribada nesters appears to be emerging at this young arribada beach.

BLACK TURTLE NESTING SUCCESS ON COLOLA BEACH, MICHOACAN, MEXICO

Cutzi Bedolla-Ochoa[1], Carlos Delgado-Trejo[1]

[1]umsnh-inirena

Fidelity to nesting sites in sea turtles allows long-term monitoring of the population to determine the status of a particular population and at the same time allows the study of the behavior of nesting distribution over time and In space and has repercussions on important aspects of the life history and conservation of sea turtles. This work makes an analysis of the spatial and temporal distribution of nests of black turtle (*Chelonia agassizii* aka *Chelonia mydas agassizii*) in a period from 1990-2000 to identify changes in the nesting behavior of this population over time and to identify The repercussions of the distribution of nesting on the conservation activities of this population in the beach of Colola, Mexico. For each "station" (west,

media1, media2, east) and "zone" (zone1, zone2, zone3, zone4 and zone5) of the beach (delimited according to thermal characteristics from high tide line to vegetation) "successful" nests (nests deposited in the first attempt to nest) and "unsuccessful" (no eggs deposited) occurred during the study period were recorded. The nesting percentage was obtained for each station and for each zone of the beach, a variance analysis (ANOVA) was applied to determine significant differences between nesting percentages by "station" and "zone" and the test of Tukey to identify the significant differences between "stations" and "zones". Successful nesting was obtained by difference between the number of nesting attempts per season and the number of nesting failures expressed as a percentage. The results show that nesting success by "station" is: west: 91.12%; Media1: 87.35%; Media2: 87.89% and east area: 86.00%. The ANOVA showed significant differences in the west station with the rest of the stations (F-radio = 7.110 P = 0.001), the percentage of nesting occurred for each zone of the beach was: zone 1: 59.55%; zone2: 86.80%; zone3: 92.66%; zone4: 90.47%; zone5: 85.34%. The analysis of variance showed a significant difference of clusters between the zones (F-radio = 13.185 P = 0.000) and the Tukey test showed that zone 3 is statistically different from the other 4 zones in relation to the number of nests; While zones 1 and 5 are statistically equal (P = 1,000) and zones 2 and 4 are also (P = 1,000). The number of nests per month was: September 87.07%; October 86.76%; November 93.10%; December 92.83%. The results indicate that the western station and zone 3 are sites with the highest number of nesting sites. The western zone is the furthest station in Colola and not subject to disturbances of anthropogenic origin, otherwise the station east of Colola. Zone 3 receives the largest number of turtle nests, this zone is characterized by being warm and flat, with no obstacles and vegetation, which favors successful nesting and the production of female hatchlings, which has important implications for the conservation of Black turtle.

UNRAVELING THE MYSTERY OF THE ARRIBADA BEHAVIOR: AN ANALYSIS OF ENVIRONMENTAL CORRELATES

Vanessa Bezy[1], Nathan F. Putman[2], Luis Fonseca-López[3], Carlos Mario Orrego Vasquez[4], Roldán A. Valverde[5], Kenneth J. Lohmann[1]

[1]University of North Carolina at Chapel Hill
[2]Cooperative Institute for Marine and Atmospheric Studies. Rosenstiel School for Marine and Atmospheric Science, University of Miami AND NOAA Atlantic Oceanographic & Meteorological Laboratory
[3]Biocenosis Marina. Trinidad de Moravia, Costa Rica
[4]Sistema Nacional de Áreas de Conservación. Ministerio del Ambiente y Energía, Costa Rica [5]Southeastern Louisiana University

During the mass nesting of olive ridley sea turtles (also known as an arribada), thousands of turtles emerge from the ocean to nest along a small stretch of beach. Little is known, however, about how turtles synchronize their behavior so that thousands emerge to nest at the same time and place. As an initial step toward unraveling the mechanisms underlying the timing of arribadas, we analyzed ten years of mass-nesting data from Ostional, Costa Rica. First, we analyzed the distribution of sea turtles on the beach and described fine-scale trends in the mass-nesting behavior. Second, we used statistical models to analyze the timing and abundance of nesting turtles in the context of relevant meteorological and oceanographic variables. The mean interval between mass-nesting events was 33.53 d ± 1.44 and the average duration of mass-nesting events was 3.39 d ± 0.15. The number of turtles participating in arribadas varied significantly throughout the year, with the largest events occurring in the months of September and October. Furthermore, significantly more turtles participated in events in the rainy season (86,953 turtles ± 10,500) than in the dry season (44,298 turtles ± 13,422). The central location of mass-nesting events along the beach varied significantly throughout each year, in accordance with changes in the season and the number of sea turtles that participated in each event. Overall, however, the central location of mass-nesting events did not

change from year to year. Initial analyses of the statistical models revealed that wind, oceanic currents, salinity, and humidity show the strongest relationship with the number of turtles participating in mass-nesting events. Results from the models also indicate that the occurrence of mass-nesting events at Ostional was most strongly related to lunar phase and sea surface height (the topography or relief of the ocean's surface). Overall, our analysis reveals the dynamic nature of mass-nesting events and suggests environmental variables may influence the mechanism by which sea turtles synchronize nesting.

EFFECT OF AGE ON THE REPRODUCTIVE FITNESS OF EAST PACIFIC LEATHERBACK TURTLES*

Jenell Black[1,2], Nathan J. Robinson[1,2], Lauren M. Cruz[1,2], Pilar Santidrián-Tomillo[3,2], James R. Spotila[4,2], Frank V. Paladino[1,2]

[1]*Indiana University-Purdue University Fort Wayne*
[2]*The Leatherback Trust*
[3]*Mediterranean Institute for Advanced Studies*
[4]*Drexel University*

Mortality rates of many endangered sea turtle populations are unsustainably high due to many factors, such as fisheries catch. When populations are faced by high mortality rates, this can affect age structure or reduce the average age of the population. In this study, we assessed whether reproductive fitness of leatherback turtles is affected by age since first-identified reproduction (henceforth referred to as "age"). To investigate how age affects reproductive fitness, we looked at a number of factors, including: growth rates, arrival at the nesting site, and clutch size. For growth rates, we discovered that age is a better determinant of growth rate than size is, where older turtles grow slower than their younger counterparts. Growth rates are 2.5 mm per year on average, with approximately 5.0 mm per year growth attributed to neophytes and 0 to nominal growth attributed to turtles that been nesting for 20+ years. For arrival at the nesting site, we discovered that older turtles arrive earlier in the nesting season. Furthermore, as conditions are more favorable early in the nesting season, nests laid during this time tend to have a higher hatching success. We discovered no influence of age on clutch size, and are currently examining age in relation to nest site selection. Age appears to strongly influence reproductive output in sea turtles. Presumably, this is because older turtles expend less energy on growth, which may allow for more energetic allocation toward factors surrounding reproductive output (larger clutches, higher egg mass, frequency of nesting intervals). This shows that older turtles are of particular value in regard to maintaining or even increasing overall population.

TIMING OF NEST EMERGENCE IN KEMP'S RIDLEY AND LEATHERBACK HATCHLINGS

Amy N. Bonka[1], Thane Wibbels[1], Ricardo F. Tapilatu[2,3], William G. Iwanggin[2,3], Hengki Wona[2,3], Yairus M. Swabra[2,3], Zadrak O. Woisiri[2], Riki M.P. Mayor[2,3], Gideon Y. Waroy[2,3], Erick Sembor[2,3], Roy Rumbiak[2,3], Blanca Zapata Najera[2,3], Laura Sarti Martinez[4], Erika Navarro Ang[4], Manual Rosas[5], Gerardo Marin[5], Francisco Illescas[5], L. Jaime Pena[6,5], Patrick Burchfield[5]

[1]*University of Alabama at Birmingham - Birmingham AL, USA*
[2]*Bird's Head Leatherback Conservation Program*
[3]*Research Center for Pacific Marine Resources - University of Papua (UNIPA) Manokwari Papua Barat Indonesia*
[4]*Comision Nacional de Areas Naturales Protegidas - Ciudad Victoria Tamaulipas Mexico*
[5]*Gladys Porter Zoo - Brownsville TX USA*
[6]*Conservacion de Espacios Naturales - Sociedad Civil - Tamaulipas Mexico*

Emergence from the nest represents a pivotal life history event which potentially enhances survival (e.g. through the avoidance of predators and heat-induced mortality). We have been using infrared wildlife cameras to evaluate emergence times in two different species: the Kemp's ridley sea turtle at Rancho Nuevo, Mexico, and the leatherback sea turtle at Bird's Head, Papua Barat, Indonesia. Our preliminary results from Bird's Head suggests a relatively early emergence time from approximately 6pm – 1am. In contrast, our results from the Kemp's ridley suggest the majority of hatchlings emerge between midnight and 8am. Temperature was evaluated as a potential cue controlling the timing of emergence. The results indicate that emergence in the Kemp's ridleys occurred at a time period during which nest temperatures are decreasing, which coincides with nighttime hours. This could potentially minimize predation from beach and near-shore predators, as well as reduce the risk of mortality due to desiccation. The apparent difference between emergence times of the two species examined in the current study suggests there may be species and/or nesting beach specific factors that affect emergence time, to potentially enhance the survival of hatchlings.

MORPHOMETRIC ANALYSIS OF NESTING OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS CORIACEA*)

Matthew Brochhausen[1], Annie Clift[1,2], Madeleine Beange[1,2], Randall Arauz[2]

[1]*Turtle Trax*
[2]*CREMA*

Olive ridleys (*Lepidochelys olivacea*) show plasticity in several aspects of their biology, including nesting behaviors, diet, and even size. The morphometry of a nesting Olive Ridley sea turtle, as well as all features of the respective nest, illustrate a large variety of size and form. This observation led to the hypothesis that there are potentials for correlations to be present between the morphometric measurements, therefore unveiling relationships that could contribute to reproductive success. Olive ridleys still remain underwhelmingly researched in all aspects of their biology, including their morphology. A better understanding of their morphology and the various relationships that could exist within it, could help us to better protect them. Over a five month period, data was recorded from solitary nesting olive ridley turtles encountered on Playa Bejuco, a 3.3 kilometer beach along the Nicoya Peninsula, in Guanacaste, Costa Rica. During the nesting process, the turtles and nests were measured with soft tape, while the eggs were

measured with calipers and relocated to the projects hatchery where the hatchling size/success could later be obtained. The variables analyzed include adult size (curved carapace length and curved carapace width), egg size (diameter), clutch size, nest size (depth and width), and hatchling size (straight carapace length and straight carapace width). Positive correlations were uncovered between adult size and nest size, adult size and clutch size, as well as egg size and hatchling size (n=30). However, there was no correlation found between adult size and egg size, nor adult size and hatchling size. These results demonstrated that larger turtles tend to dig larger holes as well as deposit larger clutches. At this time the data doesn't support a relationship between female size and the size of her eggs or hatchlings; however, with a larger sample size this could change. Data collection is planned to continue through January, and upon commencement will be added to the analysis of this study.

BEACH EROSION AND LEATHERBACK TURTLE REPRODUCTIVE SUCCESS IN PACUARE NATURE RESERVE, COSTA RICA

Renato Bruno[1,2], Nerine Constant[1,2]

[1]*Endangered Wildlife Trust*
[2]*Pacuare Nature Reserve, Costa Rica*

Beach erosion causes substantial loss of leatherback turtle (*Dermochelys coriacea*) nests and may create steep slopes and sand cliffs that potentially influence selection of nest sites by emerging females. Because beach erosion negatively affects the reproductive success of sea turtles, conservation efforts commonly adopt management strategies to mitigate the impacts of beach erosion on sea turtle nesting areas. The high-energy and erosion-prone beaches of the Caribbean coast of Central America are nesting grounds for the fourth most important leatherback turtle nesting population in the world. Pacuare Nature Reserve, located 45 kilometers southeast of Tortuguero National Park on the Caribbean coast of Costa Rica, has monitored and protected six kilometers of nesting beach north of Mondonguillo Lagoon and south of the mouth of the Pacuare River since 1994. This stretch of beach receives an average of 809 leatherback nests annually, and the monitoring project implements nest relocation to reduce the loss of nests due to beach erosion and inundation. The objectives of this study were to: 1) map indicators of beach erosion during the leatherback nesting season in Pacuare Nature Reserve, 2) quantify the effect of beach width and sand cliff height on nest site selection and hatching success, and 3) identify indicators of beach erosion that could be used to determine whether a nest should be relocated or left in situ. From 26 May to 26 July 2016, we conducted biweekly surveys to assess the presence of sand cliffs (abrupt change in beach height of >10 cm) at 25-meter intervals along the beach. If a sand cliff was present, we recorded the height and marked the location using a GPS. We mapped the vegetation line, which marks the landward limit of the beach, and the low tide line. Using ArcGIS, we measured the distance between the vegetation and low tide lines to obtain beach width at the same 25-meter intervals. Pacuare Nature Reserve provided nesting activity and hatching success data. We examined the relationship between these measures of reproductive success and our indicators of beach erosion. We found that false crawls increased significantly with sand cliff height and that nest numbers increased significantly with beach width. There was a non-significant trend for hatching success to increase with beach width, and beach width was significantly narrower for beach sections in which all nests failed (0% hatching success). Our results suggest that beach erosion in Pacuare negatively impacts leatherback reproductive success. Beach width may be a useful indicator of whether an area is at risk of eroding and should be considered when assessing the need for nest relocation.

HOW DOES BEACH NOURISHMENT AFFECT HATCHING SUCCESS IN GREEN AND LOGGERHEAD SEA TURTLES?

Kayla Burandt[1], Gustavo D. Stahelin[1], Katrina Phillips[1], Jacob R. Kelley[1], Katherine L. Mansfield[1]

University of Central Florida, Orlando FL, USA

Human impacts and climate change are potential threats to beach habitat used by many species. Climate change will likely lead to modification and loss of beach habitat due to increased storm severity and sea level rise. Human attempts to protect beaches also lead to modification with unknown ecological impacts. Marine turtles use beach habitat for reproduction, and therefore, understanding the effects of beach characteristics' alteration on these animals is needed for successful species conservation. Several turtle species nest every year on the Archie Carr National Wildlife Refuge (ACNWR) in Melbourne Beach, FL, USA. The refuge is an important nesting beach for green turtles (Chelonia mydas) and is one of the highest density nesting beaches in the world for loggerheads (*Caretta caretta*). The ACNWR is composed primarily of natural sand, however, due to erosion from storm events and beachfront development, some areas on the beach are periodically nourished. Nourishment projects strive to deposit sand that mimics the quality of what would naturally be found at the beaches they are replenishing. But nourished sand may still differ from natural sand in its physical properties such as grain size and texture. These differences may impact the environmental conditions during nest incubation. This may be problematic for nesting turtles that lay their eggs in these nourished areas. Hatching success and emergence success for nests laid in natural and nourished sand were evaluated for 568 loggerhead and 735 green turtle nests laid in between the years of 2010 and 2015. From this we assessed whether beach nourishment had a detrimental impact on nests. Using a mixed effects logistic regression model, we found that hatching and emergence success did not differ between nourished and natural sand for either green turtles or loggerheads at the ACNWR. From this we conclude that the guidelines in place for quality and sourcing of sand brought to the ACNWR mitigated potential negative effects on nests laid in nourished areas. We recommend that other projects carefully consider the type of sand used to nourish nesting beaches to maintain natural hatching and emerging success rates. These results will be important to consider in the future as continued beachfront development, sea level rise, and increased storm severity due to climate change could lead to more beach nourishment.

VALIDATING THE USE OF DRONES AS A TOOL FOR MONITORING SEA TURTLE NESTING ACTIVITY

Bridget Carroll[1], Karin Leland[1], McKenna Miller[1], Pilar Santidrián-Tomillo[2], Nathan J. Robinson[2], John Doleman[3]

[1]Student, Plymouth, Minnesota, USA
[2]The Leatherback Trust, Monterey, California, USA
[3]Seeds of Change, Wayzata, Minnesota, USA

On the Pacific coast of Costa Rica, the Gulf of Papagayo includes several small beaches that are important nesting grounds for Green turtles (*Chelonia mydas*), Leatherback turtles (*Dermochelys coriacea*) and Olive Ridley turtles (*Lepidochelys olivacea*). Sea turtle monitoring projects exists on some of these beaches, including Playa Cabuyal; however, the access of many of the smaller beaches is difficult. During this study, drones were used to enhance sea turtle research and monitoring at Cabuyal and nearby nesting beaches. We investigated the usage of drones to overcome monitoring limitations associated with beaches that are

difficult to access by foot. The capacity to discern sea turtle tracks was first tested in Minnesota, USA by using replicated tracks. After testing the ability of the drone imagery to pick up tracks in Minnesota, we traveled to Costa Rica to test the feasibility in the field. Over the course of two-dozen flights in total, we were able to distinguish tracks using imagery in both the visible and the infrared spectrum. Additionally, we were able to autonomously fly the length of a beach and capture imagery using an IRIS drone equipped with a visible spectrum camera. Following the autonomous flight, we used software to generate maps based on images obtained from the drone and created 3D maps that could be used for monitoring beach dynamics. Autonomous flights were conducted to the adjacent beaches and provided pictures of otherwise inaccessible nesting beaches. We surpassed our goal of three successful flights to the adjacent beaches. Drone flights at dawn can be used to record turtle tracks and verify nesting activities from the previous night. Being present on the beach throughout the night we were able to record where and what kind of turtles nested to confirm the flights at dawn were capable of gathering that data. Additionally, the size of the tracks can be measured from the drone imagery by using pixels to measure width of the track from a known length. There are other possible applications of this technology such as studying in water behavior of sea turtles. As technology advances the ability of drones to complement night patrols and to capture imagery of multiple beaches is possible. With further research, it may be possible to identify individual turtles as well as to monitor the physical properties of the beaches over time. Using drone technology, the ability of researchers to collect data regarding turtles may be substantially expanded.

EFFECTS OF WEATHER EVENTS ON INCUBATION PERIODS IN GREEN SEA TURTLES NESTS IN TORTUGUERO NATIONAL PARK, COSTA RICA

Alejandra Carvallo[1], Jaime A. Restrepo M.[2]

[1]GVI
[2]STC

Global Vision International, working the southern end of Tortuguero National Park, with the support of Sea Turtle Conservancy, works to conserve the local nesting green sea turtle population, covering 18 miles of the beach. The different climate events that affect the Caribbean coast of Costa Rica are likely to be having an effect on the incubation periods of sea turtle clutches. The presence of climate events due the El Niño-Southern Oscillation in particular are thought to be altering the incubation duration in green sea turtles. By the different climate events the temperature of the nest is altered, as a result the incubation periods would reduce in the presence of these fluctuations. Data collected over the past 5 years has been analyzed to compare incubation duration in periods of El Niño and La Niña, to identify whether this climate cycle is affecting incubation periods of clutches laid by Green sea turtles in the area. Throughout the year, the incubation periods in the National park differ from an average range, which would imply that the nest temperature is being compromised by the effects of ENSO.

TETIAROA GREEN TURTLE NESTING SANCTUARY IN FRENCH POLYNESIA

Gaspar Cécile[1]

[1]NGO te mana o te moana Papetoai Moorea Island French Polynesia

Since 2005, the non-profit foundation te mana o te moana (spirit of the ocean in Tahitian) has developed sea turtle research, education and conservation programs in French Polynesia. In addition to setting up a

dedicated sea turtle clinic on Moorea island, and targeted education programs for the local schools, one of its major achievements is the green turtle nesting long term monitoring on Marlon Brando's atoll: Tetiaroa. This is the only long-term survey done in French Polynesia. The presentation will highlight the nesting tracks parameters on a ten years period on this atoll. From 53 up to 555 tracks have been monitored on 8 islets out of 12 over the years with the current season 2016-2017 being the highest. Results will show the annual trends of the monitoring as well as the key information on more than 50 females parameters gathered by teams of volunteers located on the atoll. 7 tracking programs showing direct tracks to the west and mainly to Fidji area have confirmed migratory routes of post nesting females followed by Argos. Key results of hatchling success along with nests parameters will be highlighted. Uninhabited since 2004, this atoll is now welcoming The Brando Resort that opened in July 2014 and has set up particular light policies for turtle nesting season. Key information on nesting around the hotel will be shown with a large increase of tracks on the resort beachfront since its opening with a maximum level reached this year (multiplied by 7). Taking in consideration the very particular place of sea turtles in the Polynesian culture, nesting monitoring examples on Tetiaroa atoll could be used as a model for future surveys involving local people from remote islands like in the Tuamotu archipelagos. In addition to nesting monitoring, children education and awareness programs have been developed, along with an extensive citizen science program of "turtle monitors" that could be extended to all French Polynesian inhabited islands to maximize crucial data collections on sea turtles from very remote locations on an ocean territory as large as Europe. Better understanding of green sea turtle nesting trends is key for future conservation plan in a context of global changes for this threatened and migratory species in the South Pacific.

ESTIMATE THE GREEN TURTLE HATCHLINGS SEX RATIO IN TAIWAN

YinTing Chan[1], I-Jiunn Cheng[1]

[1]*National Taiwan Ocean University*

Sex ratio is an important life history trait for animals, especially the endangered species, like sea turtles. It can help us to determine the survival strategy of the species. However, the sex of sea turtles is determined by the incubation temperature during the third period of incubation. Thus, it is impossible to determine the gender of hatchling based on the morphological characters. There are three main nesting islands on Taiwan; Wan-an Island, Lanyu Island, and Liuchiu Island. In a previous study in 2010 and 2011, it was found that the sea turtle hatchlings in Taiwan are female-biased, ranging from 89 to 100%. In order to determine if the sex ratio has changed after 4 to 5 years from the previous study, we re-sampled the dead hatchlings from all three islands in the nesting seasons of 2015 and 2016 and determined their sex ratio. Hatchlings were determined by tissue section method, combining with the nest temperature during the sex-determine period.

Results show that the sex ratio for green turtle hatchlings in Taiwan is female-biased; 84% in Wan-an Island, 52% in Lanyu Island and 92% in Liuchiu Island, with the average of 73%, lower than the previous study. It is possible that the excessive rainfall during these two summers resulted in the decrease of incubation temperature during the sex determination period.

AN INVESTIGATION INTO THE EFFECT OF NEST DEPTH AND CLUTCH SIZE ON THE ECLOSION PERCENTAGE AND HATCHLING FITNESS OF *LEPIDOCHELYS OLIVACEA*

Sara de Georgio[1]

[1]*University of Manchester, England, UK*

Sea turtle hatcheries play a vital role in mitigating the decline of olive ridley turtles (*Lepidochelys olivacea*) on the pacific coast of Guatemala, where legal trade for eggs ensures no nest is left undisturbed. ARCAS (Wildlife Rescue and Conservation Association) is a non-governmental organization with four hatcheries, whose efforts accounted for 25% of all sea turtle eggs collected in the country in 2013. This study, carried out with data from October 28th to December 8th 2016, examines the effect of both nest depth and clutch size on the eclosion percentage in ARCAS' hatcheries on the Hawaii beach in Guatemala. Nests were buried at depths of 35cm, 40cm and 45cm in clutches within ranges of 16-20, 41-45 and 66-70 eggs per nest. The values for the depth of the nests deviate 5cm above and below the average nest depth for olive ridley turtles (40cm), while the ranges of eggs per nest is based on the three nest sizes with the highest eclosion percentage from 2015 hatchery data. Depth and clutch size will most likely affect the nest temperature. Deeper nests are shielded from diurnal fluctuations in temperature caused by solar radiation and outside air temperature. It has also been demonstrated in previous studies that nests of smaller clutch sizes have a lower mortality rate due to less metabolic heating within the nest. Detailed exhumations of these nests provided information on how external factors affect the development of unhatched eggs. In this study, the results showed that there were no statistical differences between the eclosion percentages of the different treatments. However, when analysed separately, a strong trend was apparent between clutch size and the eclosion percentage (P=0.0728), showing that larger nests (66-70 eggs) had a lower eclosion percentage, supporting the above findings. The eclosion percentage of the larger nests decreased as nest depth increased from 35 to 45cm, which contradicts the initial prediction of this study.

TYPHOON DOLPHIN: PRE-AND POST-DISTURBANCE NESTING SEASONS HIGHLIGHT NESTING HABITAT PREFERENCES OF *CHELONIA MYDAS* ON ANDERSEN AIR FORCE BASE, GUAM

Jessica DeBlieck[1], MaryLou Staman[1], Joshua J. Salas[1], Jennifer Cruce Horeg[2], Terry J. Donaldson[1]

[1]*University of Guam*
[2]*Andersen AFB Guam*

On May 15, 2015, Typhoon Dolphin passed over Guam, clearing vegetation from 3 active *Chelonia mydas* nesting beaches. Little is known about nesting habitats of *C. mydas* on Guam and the effects of vegetation removal on nesting females were unknown. Data collected through daily surveys included the dates when nests were initially laid, pinpoint nesting locations (GPS coordinates), classification of nesting habitat preferences (open beach, shoreline vegetation, and beach forest), and other relevant data. Utilizing pre- and post-typhoon nesting data, we found nesting females travelled farther inland post-disturbance to nest along the shoreline vegetation. This discovery has been applied to aid in the prevention of intentional vegetation removal on active nesting beaches on Andersen Air Force Base and to emphasize areas of focused conservation management.

BETA TESTING NESTING SAFE - NEW TECHNOLOGY FOR NEST FINDING AND ENVIRONMENTAL TEMPERATURE MONITORING*

Stephen G. Dunbar[1,2,5,7], John Bonardelli[3], Emily Manzano[4,5], Ryan De La Garza[4,5], Denny Estevez[6], Lidia Salinas[1,7]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research. Inc. (ProTECTOR Inc.), Loma Linda, CA USA
[2]Marine Research Group, Department of Earth and Biological Sciences. Loma Linda University, Loma Linda, CA USA
[3]Nesting Safe AS, Trondheim 7020, Norway
[4]Department of Biology, Southwestern Adventist University, Keene, TX USA
[5]ProTECTOR Inc. Volunteer and Internship Program
[6]Research Consulting Group, Loma Linda University, Loma Linda, CA USA
[7]Protective Turtle Ecology Center for Training, Outreach, and Research - Honduras (ProTECTOR - Honduras), Tegucigalpa, Honduras

Locating turtle nests is a challenge, especially on beaches where nest markings allow nest poaching. Yet, regularly locating and monitoring nests in situ during incubation are vital for understanding interactions of climate change, nest temperatures, egg development, and sex ratios. Furthermore, monitoring environmental temperatures is critically important in understanding sea turtle nesting biology. However, monitoring environmental temperatures in situ during nest incubation or dynamic beach conditions without disrupting the nest or nearby environment has, until now, remained a difficult challenge. This is because previous technology did not permit external monitoring of the devices after burial. Thus, temperature data could neither be detected nor displayed until the monitoring term ended. In some cases, logger failures resulted in loss of time and valuable data. Nesting Safe developed an innovative application of Radio Frequency Identification (RFID) technology to detect specially designed CRADAL (Concealed RADio Activated Localization) nest tags and temperature loggers addressing issues of relocating turtle nests and monitoring beach environments. Using a responsive mobile application to record geo-referenced nesting events and temperature loggers allows real time monitoring of nests with selected upload of in situ data. After uploading to a referential database, nest emergence times and temperatures are visualized in real time. We tested Turtle Nesting Safe Professional technology in two field applications. First, we deployed nest CRADAL tags on 5 beaches in countries at variable latitudes to validate positioning and map visualizations in the database. Some nests were relocated to hatcheries with associated tags moved to continue monitoring. We also deployed 2 temperature loggers with integrated sensors, and 2 loggers with 50 and 100cm probes to measure nest temperatures at different nest depths. Second, we deployed 16 hermetically sealed data loggers on a nesting beach in Utila, Honduras from July 4 – July 28, 2016 in a beach pollution experiment in four corridors with varying amounts of debris coverage to monitor surface sand temperatures. Four RFID temperature loggers were placed in each corridor and set to log temperatures every 20 minutes. Temperature loggers were scanned in situ every 4 – 5 days, and data saved in an offline mode on a mobile tablet until uploaded with an Internet connection. Temperature data were automatically stitched in the web database and later analyzed by ANOVA. We referenced 10 nests and were able to relocate all unmarked nests, and monitor in situ temperatures in both natural and relocated nests daily without having to mark or disrupt nests in any way. In Honduras, we found sand temperatures were significantly lower for the high-density pollution corridor than for the control corridor by 0.6C during the day and by 0.71C overnight. These and other results demonstrate that Turtle Nesting Safe Professional technology can facilitate real-time nest locating, and nest and environmental temperature monitoring in situ. The ability to both locate nests and carry on in situ nest and environmental temperature monitoring without disrupting incubation has the

potential to provide new insights into factors that influence hatchling success and sex ratios in response to global climate change.

TURKISH SEA TURTLE NESTING TRENDS: EVALUATION OF THE DATA COLLECTION

İrfan Ekmekçi[1], Mahmut Akan[1], Yakup Kaska[2]

[1]Turkish Ministry of Environment and Urbanization, Department of Environment Impact Assessment, Ankara
[2]Turkish Ministry of Forestry and Water Affairs, General Directorate of Nature Conservation and National Parks, Ankara.

Loggerhead and green turtles nest on the beaches of the Turkish Mediterranean Coast. These beaches have been monitored by different groups of Volunteers and supervised by the University researchers. There are 21 beaches identified as sea turtle nesting beaches with a total length of 290 km. The Loggerhead turtles nest mainly western beaches and the green turtle nest on the eastern beaches. We evaluated the number of turtle nests on all beaches starting in 1988. During these years, there were 42 MSc theses and 16 PhD studies carried out by the Universities on sea turtles along these beaches. There were clearly some fluctuations in nest numbers on the same beach by different years, this may be related to the nesting behavior of the turtles, could be related to the methodology used by the teams monitoring the beach. There were between 771 and 5766 annual nest counts of loggerhead turtles all along the 21 beaches. The green turtle nests were somehow between 461 and 3504. There are 11 beaches monitored every year on a daily basis, there are few others monitored irregularly by the nearby teams. There are two Ministries responsible for the monitoring of the beaches. The Ministry of Environment (1) is responsible for specially protected beaches, whereas the remaining beaches were under the control of the Ministry of Forestry and Water Affairs (2). Here we combined and put together all available data by combining the two ministries. We also discussed the better way of monitoring the beaches and creating a database for the Turkish Sea Turtle network.

NEST TO SURF MORTALITY OF LOGGERHEAD SEA TURTLE HATCHLINGS ON FLORIDA'S EAST COAST*

Victoria Erb[1], Jeanette Wyneken[1]
[1]Florida Atlantic University

Robust measures of hatchling production rates are fundamental for characterizing demographics and establishing species management plans for imperiled species. Worldwide, sea turtle hatchlings are an especially vulnerable life stage. Many beach monitoring programs measure sea turtle hatchling production from nest inventories. These inventories show trends in nesting success, but rarely account for hatchling mortality that occurs post-emergence leaving a demographic data gap. This gap produces incomplete estimates of hatchling production. It is likely that natural predators, beach vegetation, and anthropogenic factors can cause mortality during the journey from nest to surf. This study addresses this data gap for Florida's important east coast nesting assemblages of loggerhead sea turtles (*Caretta caretta*). Five study sites along Florida's Atlantic coast (26.33908, -80.07051 to 28.89465, -80.80014) were surveyed to measure nest-to-sea mortality and account for variation due to location or level of urbanization. Infrared time-lapse cameras, night vision optics, and morning track maps were used to quantify hatchling mortality. Nest to surf mortality was observed at all locations and overall, we estimated that 7% of hatchlings did not make it to the water. Mortality sources varied by location. Observed predators include: foxes, bobcats,

yellow-crowned night herons, ghost crabs, and gulls. Hatchling disorientation was more frequent and severe in urban areas versus natural areas. Some disoriented hatchlings survived; however, other hatchlings were observed entering vegetation, getting stuck, and succumbing to ant (Solenopsis invicta) attack. This study provides the first systematic measures of nest to surf morality and identifies a particularly vulnerable period in a hatchling's life. This information will contribute to more comprehensive life history models, which serve as foundations of conservation management plans.

TEMPORAL PATTERNS OF SEA TURTLE HATCHLING EMERGENCE AT A HAWKSBILL NESTING BEACH ON JUMBY BAY, ANTIGUA

Alexandra L. Fireman[1], Andrew S. Maurer[1], Seth P. Stapleton[1]

[1]*Jumby Bay Hawksbill Project, Jumby Bay, Antigua*

It is generally accepted that sea turtle hatchling emergence events most frequently occur at night. However, empirical evidence of temporal patterns of hatchling emergence in hawksbills (*Eretmochelys imbricata*) is lacking, and the potential drivers of these patterns are not well understood. We hypothesized that variability among nesting site habitats and broader climatic patterns are among the factors that may explain patterns in emergence times at our study site on Jumby Bay, Antigua, West Indies. To describe general patterns of emergence and assess factors that may affect emergence time, we analyzed data collected during June through November, 2005 – 2016, at our nesting site. This beach is intensively monitored by the Jumby Bay Hawksbill Project during the primary nesting season. Hatchling emergence events were observed during hourly patrols over the entirety of the nesting season, nest habitat metrics were recorded at the time of egg deposition, and hatching success data were collected post-emergence. Our data indicate that for emergences occurring after the first patrol at around 8pm, the peak hatchling emergence time is from 8-9pm, with emergence events decreasing each subsequent hour until sunrise, around 5am. This suggests that emergences are influenced by the onset of darkness (likely due to a decrease in ambient temperature), although, we note that a significant number of hatchling emergences did occur prior to the initiation of patrolling. We use a regression framework to assess the relationship of shade cover, vegetative cover, clutch size, hatching success, nest depth, incubation duration, and climatic factors to hatchling emergence times. Our data provide empirical evidence to help inform future conservation and management efforts, including underscoring the importance of light management, particularly early in the evenings, to ensure that hatchlings orient properly as they head to sea.

A TURTLE HERE, A TURTLE THERE, ARE THERE TURTLES EVERYWHERE? - AN EXAMINATION OF LIGHTING DISORIENTATIONS IN PINELLAS COUNTY, FL DURING THE 2016 MARINE TURTLE NESTING SEASON

Andie M. Fisher[1,2], Lindsey N. Flynn[1], Laura J. Wright[1]

[1]*Clearwater Marine Aquarium*
[2]*Bowling Green State University*

It is well known that one of the leading contributions to the disorientation of marine turtles, both adult and hatchling, is artificial lighting. To assess the effects artificial lighting may have had on marine turtles utilizing nesting habitat in Pinellas County, Florida, all observed disorientation events were documented by Clearwater Marine Aquarium (Clearwater, Florida) during the 2016 nesting season. These events were

reported using forms provided by Florida Fish and Wildlife Conservation Commission. Reports were compiled and analyzed to identify what, if any, municipalities had a greater number of disoriented turtles compared to neighboring locations. This study found that there was a significant difference in the number of disorientation events that occurred over time in the 10 municipalities studied (p= 0.0005), with the most significant difference between Clearwater Beach and Redington Shores (p=0.0007). However, the number of hatchlings disoriented within each municipality did not vary over time, for either the high estimation (p=0.09) or the low estimation (p=0.08) of disoriented hatchlings. While these findings may be due to the inherent error introduced in the method of reporting, it illustrates that there a remarkable difference in the number of disorientation events occurring throughout the nesting season in Pinellas County and future studies may help coastal stewards focus their conservation efforts. This study also shows a need for a more discriminative method of reporting the total number of disoriented hatchlings per event to more accurately elucidate the severity of disorientation events.

THERMAL REACTION NORM FOR SEXUALISATION: THE MISSING LINK BETWEEN NEST TEMPERATURE AND SEX RATIO*

Marc Girondot[1], Richard C. Vogt[2], Jonathan Monsinjon[1], Camilla Kurzmann[2], Jean-Michel Guillon[1]

[1]Ecologie Systématique Evolution, Université Paris Sud CNRS AgroParistech and Université Paris Saclay, France
[2]Instituto Nacional de Pesquisas da Amazonia, Manaus, Brazil

Fifty years after the discovering of temperature-dependent sex determination (TSD) in reptiles in an Agamid lizard and hereafter in many turtles, and all crocodilians and tuataras, the evolutionary origin and ecological consequences of TSD is still puzzling. One of the origins for this unresolved puzzle come from the way this field has developed. The first years after this discovery were occupied by solving the biochemichal origin of this particular sex determining system using incubations at constant temperature. Very soon the situation in nature was studied and was much more complicated: sexual phenotype of the gonad is influenced by temperature during a window of development lasting the middle third of development. The integration of temperature change during this middle third of development was unknown and is still unknown. Mrosovky proposes to link the incubation duration observed at different constant incubation temperatures with observed sex ratio. This solution works good at constant temperature but, as early as 1994, it was demonstrated very elegantly that incubation duration was a very bad proxy of sex ratio. Nevertheless, this proxy has been used intensively and is still used: we know that this method can give 100% error but it is widely used! An alternative method is to convert incubation temperatures into Constant Temperature Equivalent. It was proposed that weighting scheme should take into account the rate of development of embryo with the idea that the fraction of development at different temperatures could explain sex ratio. We test this hypothesis in 3 species (*Caretta caretta, Podocnemys expansa, Emys orbicularis*) and we show that it is not sufficient to explain the sex ratio: a new thermal reaction norm is needed to be able to fit the observed sex ratio: the thermal reaction norm for sexualisation: it explains why embryos incubated at 32°C and 35°C are both 100% feminized but the latter are more feminized than th former. Using this concept, we were able to much better predict sex ratio from timeseries of temperatures.

EMERGENCE TIMING OF LEATHERBACK HATCHLINGS AT SANDY POINT NATIONAL WILDLIFE REFUGE 2010-2014

Claire Gonzales[1], Kelly R. Stewart[1]

[1]The Ocean Foundation, 19th St. NW Washington D.C., 20036

Leatherback sea turtles are listed as Vulnerable globally by the IUCN. To preserve this species, we must protect their reproductive processes, particularly hatchlings from emerging nests. We studied the timing of emergence of hatchlings at Sandy Point National Wildlife Refuge (SPNWR), one of the most-studied leatherback nesting beaches in the world. Using nesting data from the 2010-2014 nesting seasons, we surveyed 524 nests and evaluated the time that hatchlings began emerging, the time that they finished emerging, the incubation durations, and the total number of hatchlings that emerged on the initial pulse of emergence. Consequently, we determined that in situ nests (nests naturally occurring and not manipulated) developed with an incubation period of 61.4 ± 21.1 (n = 332) days, began hatching at 18:25 and finished hatching at 19:06, while relocated nests (nests that had been moved at deposition because of erosion threats), developed with an incubation period of 60.0 ± 2.7 (n = 192) days, began hatching at 18:27 and finished hatching at 19:03 (on average, for all years combined). First emergences from these nests yielded 36.6 ± 21.1 hatchlings from in situ nests and 14.9 ±13.6 hatchlings from relocated nests. Green, hawksbill and loggerhead turtles have all been observed to begin emerging once the sun sets and continue emerging throughout the night. In contrast, our findings reflect that leatherback sea turtle hatchlings emerge earlier in the evening than other sea turtle species, with emergence often beginning before sunset; they usually do not continue to emerge through the night. To allocate resources most effectively, beach management programs at SPNWR should be maximized between 17:00 and 19:00, the period when most nests are emerging and require the most protection from predators. This work provides important information about the timing of leatherback hatching. In future years, we should continue to monitor leatherback hatching tendencies at SPNWR to ensure that our nest protection is maintaining its efficiency and is protecting hatchlings during their most vulnerable crepuscular time frame.

NESTING STRATEGIES OF INDIVIDUAL LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON BALD HEAD ISLAND, NORTH CAROLINA*

Emily E. Hardin[1], Brooke Milligan[1], G. Christopher Shank[1]

[1]Bald Head Island Conservancy

The Bald Head Island Conservancy (BHI Conservancy) is located on Bald Head Island, North Carolina (33°52′2″N 78°0′24″W). In 2014, the US Fish and Wildlife Service designated Bald Head Island a critical nesting habitat for loggerhead sea turtles (*Caretta caretta*), highlighting the need to understand sea turtle nesting population dynamics in the region. Since 1986, BHI Conservancy scientists have directly observed 80% of the nesting mothers during the nesting process, which has facilitated full-saturation tagging of the nesting loggerhead sea turtle population. All intercepted turtles have received flipper tags (since 1991) and PIT tags (since 2002), allowing for an examination of nesting strategy trends of individuals who have nested on Bald Head Island (at least 4 separate seasons required for study inclusion). Bald Head Island loggerhead females exhibited average inter-nesting durations of 16 ± 6 days, while the average inter-season duration was 3 ± 1 years. Individual yearly average inter-nesting durations ranged from 14 to 20 days, and did not differ significantly among individuals (p-value>0.05). Average inter-season durations, ranging

from 2 to 4 years, did differ among individuals (p-value<0.05). Individuals also exhibited differences (p-values<0.05) in yearly average clutch sizes (ranging from 109 to 150 eggs), hatching success rates, defined as the number of turtles that emerged from their eggshell (ranging from 39 to 86%), and the average number of nests laid per year (ranging from 2 to 4). We also examined differences in nesting strategies between experienced (previously tagged) mothers and inexperienced (untagged) mothers. (NOTE: since we intercept only 80% of nesting mothers, it is possible that an 'inexperienced' mother had prior nesting experience). A statistically higher percentage (p-value<0.05) of experienced mothers laid multiple nests (77%) within a season compared to inexperienced mothers (29%). The average incubation time for both new and returning mothers was about 57 days (no statistical difference between experienced and inexperienced). Clutch size data also showed no significant difference in average clutch sizes, with new mothers laying an average of 112 ± 12 eggs, and experienced mothers laying an average of 117 ± 24 eggs. Hatching success of incubated eggs did not differ between groups either (experienced mothers 75 ± 13% and inexperienced mothers 73 ± 14%). We conclude that while nesting mothers enact similar timing in their nesting patterns, great variation in individual females' reproductive output and hatching success exists. This study offers unique insights into the nesting strategies of individual loggerhead sea turtles whose nesting spans up to 24 years.

IMPACTS OF BEACH RENOURISHMENT ON NESTING TRENDS OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON BALD HEAD ISLAND, NORTH CAROLINA

Emily E. Hardin[1], Brooke Milligan[1], G. Christopher Shank[1]

[1]*Bald Head Island Conservancy*

Bald Head Island, in southeastern North Carolina, is located adjacent to the Bald Head Channel Range section of the Wilmington Harbor Navigation Channel. At its closest point, the channel sits less than 120 m from the intersection of Bald Head Island's southward and westward facing beaches. This close proximity has resulted in accelerated erosion rates along these beaches. As a means to protect homes and infrastructure, beach renourishment projects have been ongoing since 1991. Bald Head Island has been designated as a critical nesting habitat for loggerhead sea turtles (*Caretta caretta*), and Bald Head Island Conservancy scientists have been conducting nightly beach patrols and collecting nesting data since 1983. This 33 year dataset allows us to investigate effects of beach renourishment on Bald Head Island's nesting loggerhead sea turtles. Data collected by Bald Head Island Conservancy scientists include number of nests and false crawls, nest relocation frequency, and hatching success of nests laid in the renourished section of Bald Head Island. With this information, the potential influence of renourishment on incubation rates, hatching success, and straggler numbers, as well as nesting, false crawl, and relocation frequencies can be examined. The interplay of these six factors was compared for 0 years, 1 year, 2 years, 3 years, and ≥4 years post-nourishment. Preliminary results indicate that none of the factors examined showed a statistically significant relationship to post-nourishment time (all p-value>0.208). Thus, for Bald Head Island, loggerhead sea turtle nesting population dynamics do not appear to be negatively impacted by beach nourishment projects. Conversely, it is possible that beach nourishment confers a benefit by helping sustain a wide beach profile allowing for ample nesting space on Bald Head Island.

THE ROLE OF ENVIRONMENTAL ACOUSTIC CUES IN SEA-FINDING OF HATCHLING LOGGERHEAD SEA TURTLES

Bethany Holtz[1], Wendy E. D. Piniak[2], Matthew H. Godfrey[2]

[1]Department of Environmental Studies. Gettysburg College, Gettysburg, PA 17325, USA
[2]North Carolina Wildlife Resources Commission. Beaufort, North Carolina 28516, United States of America

Light is the primary orientation cue used by hatchling sea turtles emerging from the nest. Among the secondary cues that have the potential to play a role in sea-finding is auditory stimuli. We measured the behavioral responses of hatchling loggerhead sea turtles collected from nesting beaches in North Carolina in the presence of recorded beach surf sounds. Hatchling loggerheads are able to detect aerial acoustic cues between 50 and 1600 Hz, but are most sensitive (have best hearing) between 50 and 400 Hz. Beach wave and surf sounds are low-frequency with the highest energy below 1000 Hz, which overlaps with the most sensitive hearing range of loggerhead hatchlings. In our previous studies using a Y-maze we observed acoustic orientation, but our results were confounded by inconsistencies in the acoustic field within the maze. To address this, we developed a new testing arena, modeled after the circular design used in other hatchling sea-finding orientation studies. We placed hatchlings in a circular arena isolated from visual, vibratory, and chemical cues. We placed a speaker producing recorded beach surf sounds outside a light-proof tent containing a level circular platform surrounded by 36 converging bins of equal length. We mapped the produced sound field throughout the arena at multiple presented sound pressure levels. We placed a single hatchling in the middle of the arena and waited 5 minutes for it to crawl into one of the surrounding bins. We compared the location of the hatchling's chosen bin to the location of the speaker to determine whether the turtle was oriented toward or away from the sound source. To avoid biases, we alternated the speaker location around the arena in relation to compass bearings of North, South, East and West. We examined the phonotaxic behaviors of the hatchlings at three sound pressure levels based on levels measured at several nest locations during varying tidal and wind conditions (60, 70 and 80 dB re: 20μPa measured at the hatchling start location). Each turtle was tested in two trails, either a no sound trial followed by a sound trail or two sound trials of differing sound pressure levels. Each trial was video recorded using an infra-red camera to analyze the time taken and path traveled by the turtles to their bin. We found a shorter orientation time (mean=131.6 ± 10.9 seconds) for the turtles' second trial in the maze for turtles that were exposed to two sound trials, while turtles that were exposed to a no sound trial followed by a sound trail had a longer orientation time (mean=117.5 ± 9.8 seconds) in their second trial in the maze. We will present our analysis of hatchling orientation with respect to the speaker location (towards or away from the wave sound) by utilizing circular statistics. Additional research is needed to further examine the biological significance of hatchling hearing and address potential impacts of terrestrial anthropogenic sounds.

LOW HATCHING SUCCESS OF LEATHERBACK TURTLE NESTS CAUSED BY THE IMPACT OF ROOT INVASION AT WERMON NESTING BEACH, BIRD'S HEAD SEASCAPE, PAPUA – INDONESIA

William Geif Iwanggin[1], Ricardo F. Tapilatu[1,2], Hengki Wona[1], Zadrak O. Woisiri[1], Yairus M. Swabra[1], Theofilus J.O. Ampnier[1], Petrus P. Batubara[1], Riki M.P. Mayor[1], Erick Sembor[1], Roy Rumbiak[1], Amy N. Bonka[3]

[1]Bird's Head Leatherback Conservation Program, Research Center for Pacific Marine Resources. University of Papua (UNIPA). Manokwari, Papua Barat Province, Indonesia
[2]Marine Science Department, University of Papua (UNIPA). Manokwari, Papua Barat Province, Indonesia
[3]Department of Biology, University of Alabama at Birmingham (UAB). Birmingham AL, USA

Wermon beach, located in the Bird's Head Seascape, Papua Barat, Indonesia, is one of the primary nesting beaches for the leatherback (*Dermochelyscoriacea*) sea turtle in the Western Pacific. Leatherback nesting at Wermon occurs in two seasons: Austral Summer (October to March) and Boreal Summer (April-September). During the Austral Summer nesting season, the beach is steep and narrow,and the tide and the waves often reach the vegetation line along the length of the beach. Further, during the Austral Summer many nests are laid below to the high tide lines. Therefore, nests must be removed from their initial location and relocated to an area of beach above the tidal limit. Conversely, during the Boreal Summer season, tides and waves do not reach the vegetation line, and therefore nests laid at Wermon during this time are not under threat of tidal inundation and the beach exhibits ideal conditions for leatherback nesting. However, currently new problems have been encountered during both nesting seasons. The spread of grass (*Ipomoea* sp.) has resulted in coverage of almost the entire area of Wermon nesting beach (90%). This directly impacts nests laid on this beach. A sub-set of leatherback nests were re-located to areas of the beach above the high tide line and these nests were evaluated for hatching success during the Boreal Summer 2016. Hatching success was low, ranging from 0 to 24.19%, with a mean hatching success of 4.13 ± 8.93% (±1 SD; n = 13), and no successful emergence from the nests recorded (0% emergence). Similar results were reported from hatching success evaluations conducted by other groups working on Wermon beach during the BorealSummer 2016 nesting season. The low hatching and emergence success is primarily due to the aggresive invasion of the nest by the roots of the Ipomoea sp. plants. These roots grow quickly during the incubation period and choke the nest. Upon nest excavation, eggs were found to be completely damaged and covered by roots. Further, hatchlings within the nest chambers were found dead due to root oppression. To mitigate the problematic invasion of Ipomoea sp. roots at Wermon beach, nests were relocated to a 6m x 6m hatchery (accomodating approximately 36 nests) during the Austral Summer 2016. Prior to hatchery construction high-intensity, aboveground mechanical removal of Ipomoea sp. plants and roots was implemented. This effort resulted in hatching success ranging from 0 to 90.14%, with a mean hatching success of 49.54 ± 28.65% (± SD; n = 36). These results suggest this process improves hatching success and hatchling emergence success at Wermon beach. The results of this study have major implications for hatching success, one of the limiting factors in the recovery of the Western Pacific leatherback.

LEPIDOCHELYS OLIVACEA EMBRYONIC DEVELOPMENT AND NEST MICROENVIRONMENT MODELS AND INTERPRETATIONS AT OSTIONAL NATIONAL WILDLIFE REFUGE, COSTA RICA

Jean Wai Jang[1], Roldán A. Valverde[2,3], Marc Girondot[4,5]

[1]*Royal Roads University*
[2]*Southeastern Louisiana University*
[3]*Sea Turtle Conservancy*
[4]*AgroParisTech*
[5]*Université Paris-Sud*

The *Lepidochelys* genus is recognized for their extraordinary mass aggregate and solitary nesting behaviour. Ostional National Wildlife Refuge, Costa Rica supports the second largest Olive Ridley marine turtle *Lepidochelys olivacea* nesting rookery worldwide. As a multiuse wildlife refuge, the community can legally harvest eggs for personal consumption and socioeconomic gains. Identifying distinct beach environments for hatchling production can inform us of population dynamics. A descriptive and predictive analysis approach was used to evaluate the quality and utilization of nesting habitat. Beach profiles based on a multinomial logistic regression analysis and maximum likelihood theory illustrate the proportion of embryonic development relative to its position on the beach width and time of season. The fate of embryos at Ostional beach was found to be dependent upon its nest density, position relative to the high tide line, and beach width. The greatest proportion of fully developed stage 5 embryos was found at the narrowest beach section Rayo 1 when egg densities were 300-400 eggs per 1 x 1 m. The first arribada of the season produced the greatest number of fully developed embryos. As the nesting season progressed the proportion of fully developed embryos decreased, with the lowest proportion of developed embryos found in December, the final nesting of the season. The probability for embryonic development is illustrated in heat maps of predictive multinomial logit models. The actual observed values are displayed for embryo development and the potential predictive values with the position of the egg on the beach width relative to the high tide line. The highest probability for embryo development 0.8 was found at Rayo 1, in areas closer to the vegetation boundary during the first arribada nesting of the season. The second highest probability for embryo development 0.4, occurred in beach sections Rayo 1 and 2 in all microenvironments during the first and second arribada nesting of the season. A probability of < 0.2 for embryos to hatch was observed throughout October, November and December arribadas in other beach sections. Identifying distinct microenvironments and understanding the incubation potential of the beachscape can lead to prioritizing key areas for conservation and effective adaptive management approaches.

TEMPERATURE AND SEX: A DETAILED ANALYSES OF A SEASON ON DALYAN BEACH, TURKEY

Yakup Kaska[1], Doğan Sözbilen[1], Eyup Başkale[1], Yusuf Katılmış[1], Musa Azmaz[1]

[1]*Pamukkale University, Faculty of Arts and Sciences, Department of Biology, Denizli, Turkey*

Temperature is an important factor for sea turtles, since they possess temperature-dependent sex differentiation owing to the absence of their sex chromosomes. Temperatures of loggerhead nests and sand temperatures on Dalyan beach were recorded and estimated by measuring temperatures of the nests and by analyzing the incubation durations and the period of emergences asynchrony. The aim of this study was to

estimate hatchling sex ratios in the loggerhead turtle (*Caretta caretta*) and show the changes in sand temperatures according to distance to the sea on Dalyan beach during 2016 breeding season. To estimate sex ratios, electronic temperature recorders were placed in 29 nests. Over the season, the mean nest temperatures during the incubation periods recorded as 30.26±0.89°C (ranged from 28.6 to 33.1°C) while the mean temperature in the middle third of the incubation period ranged from 28.9 to 32.8 °C and incubation period ranged from 46 to 61 days. The mean temperature during the middle third of the incubation period is a good indicator of the sex ratio of the clutch. Using the mean temperature during this period, it was calculated that, each of these nests, 40-100 % of the hatchlings were females. The nests at the beginning of the season (29.41 oC) produced more males with relatively longer incubation periods (61 days) and later in the season (33.1 oC) with 46 days of incubation periods. The sand temperature analyses showed that sand temperature varied with the distance from the sea. Furthermore, there was a positive correlation between the temperature and the distance from the sea. This sex ratio result contrasts with the highly female-skewed sex ratios in loggerhead turtles elsewhere; Dalyan has a relatively high proportion of male hatchlings. Dalyan beach is an important nesting ground for endangered loggerhead sea turtles because survival of sea turtle populations depends on the production of offspring of both sexes. The results analyzed both seasonal and temporal distribution of the nests on the beach. The nests laid in early May (54.3%), late May (55%), June (67%) and July (82%) produced quite remarkable male (overall 40%) proportions.

INVERTEBRATE INFESTATION IN LOGGERHEAD TURTLE (*CARETTA CARETTA* L.) NESTS, IN FETHIYE, TURKEY

Yusuf Katılmış[1], Eyup Başkale[1], Musa Azmaz[2], Doğan Sözbilen[1], Yakup Kaska[1]

[1]*Pamukkale University, Faculty of Arts and Sciences, Department of Biology, Denizli, Turkey*

The infestation of some invertebrates in loggerhead turtle nests, *Caretta caretta*, was carried out during the summer of 2016 on Fethiye beach, Turkey. A total of 84 intact loggerhead turtle nests were investigated in terms of the invertebrate faunal composition of the eggs and hatchlings at Fethiye beach from July to September 2016. The specimens, identified to order, family or genus levels. The specimens, identified in these nests, representing 5 orders were recorded. These consist of 29 (34.52%) Diptera larvae, 16 (19.04%) Pimelia sp. (Coleoptera: Tenebrionidae) larvae, 5 (5.95%) Enchytridae (Oligochaeta), 5 (5.95%) Cryptostigmata (Acari), 3 (3.57%) Elateridae (Coleoptera), 3 (3.57%) Dermestidae (Coleoptera) and 2 (2.38%) Myrmeleontidae (Neuroptera) that were found in 84 intact loggerhead turtle nests. The larval damage of Pimelia sp. were detected in 50 eggs while the family of Elateridae were recorded in 7 eggs. In addition to these, Dipteran larvae were observed in 77 eggs and in the soft tissues of 31 dead hatchlings. Furthermore, some taxons belonging to the Enchytridae family and members of Cryptostigmata were found in 17 eggs and in 14 eggs respectively. The rest of the groups were encountered in the sand of nest chambers. The results discussed the potential effect of the invertebrate infestation in hatching success of loggerhead turtle nests on Fethiye beach.

HATCHING SUCCESS AND POPULATION TREND IN DALYAN, TURKEY

Yusuf Katılmış[1], Eyup Başkale[1], Musa Azmaz[1], Doğan Sözbilen[1], Yakup Kaska[1]

[1]Pamukkale University, Faculty of Arts and Sciences, Department of Biology, Denizli, Turkey

Dalyan beach is one of the most important and best protected nesting sites of Loggerhead turtles (*Caretta caretta*) in Turkey. The regular monitoring of the beach started in 1988 and we know that the sexual maturity age is somehow between 20-25 years. The minimum nest number occurred in the 1994 nesting season as 86 nests and the maximum nest was observed in 2016 nesting season as 658 nests. We recorded a total of 1634 emergences in 2016, of which 658 (40.3%) resulted in nests respectively. 33781 hatchlings emerged (70.75%) from 47745 eggs and 29617 (87.7%) hatchlings reached to sea from these nests in 2016 nesting season. As a result of analyzing data, a remarkable record of nest count increase occurred during the last 12 years. This population fluctuation cannot be explained with an increase in the population especially increasing numbers in the last 4 years. There are two possible explanations of these increases in the nest: the first, as a result of continuous monitoring and protection efforts since 1988, the population trend of loggerhead sea turtle increased with recruitment of new mothers that has started to lay eggs. The second, nesting females that use other beaches as a breeding site, could contribute to the Dalyan population. This matter is not proved briefly yet and further studies were needed. Otherwise, tag loss is an important problem for long-term studies for monitoring of nesting individuals. In this case, we started to mark individuals from right and left flippers. Nevertheless, protection against predation also increased hatching success. Reported increasing hatching success were varied between 60-80% since 2010. Consequently, both nest number and hatching success have shown a remarkable increase on Dalyan beach.

USING MULTIPLE PREDICTORS TO EVALUATE LIPID CONTENT OF UNHATCHED GREEN SEA TURTLE (*CHELONIA MYDAS*) EGGS

Bri K. Kimmel[1], Ryan M. Chabot[1], Katherine L. Mansfield[1]

[1]University of Central Florida, Orlando, Florida

In placental mammals, embryos are continuously provided nourishment throughout development. In contrast, egg-laying organisms instead encapsulate embryos within an external shell, where nourishment is provided by a yolk. The egg yolk, composed of lipids, proteins, and carbohydrates, is still derived solely from direct female inputs. As capital breeders, sea turtles obtain energy required for reproduction at distant foraging areas, either forgoing or negligibly feeding during the nesting period. Egg lipid content could be an influential factor in determining the overall health and survival of emerging hatchlings.In this study, we investigated potential drivers of lipid content within green turtle (*Chelonia mydas*) eggs. Three unhatched, undeveloped eggs were collected from 40 nests laid in the Archie Carr National Wildlife Refuge, FL, USA, over a 10-week period during the peak nesting period during the 2013 and 2014 seasons. To determine the lipid content of these eggs, we extracted lipids from weighed subsamples of dried egg material using a soxhlet device, and then reweighed the subsample to determine the mass lost during lipid extraction. Stable isotope values of $\delta^{13}C$ and $\delta^{15}N$ were also obtained for these eggs. These values, incorporated at foraging areas through diet, may act as tracers of how quality and quantity of resources at these locations impacts egg lipid content. We used a model selection framework to evaluate simple, additive, and multiplicative models to evaluate multiple potential predictors of lipid content: straight carapace length, $\delta^{13}C$ egg mean, $\delta^{15}N$ egg mean, ordinal lay date, and year. The top five models ($\Delta AIC<2.0$) included the null model,

indicating limited explanatory power for the models and predictor variables examined. However, the 4 models aside from the null all included $\delta^{15}N$ egg mean, while two contained $\delta^{13}C$ egg mean and the interaction of $\delta^{13}C$ egg mean and $\delta^{15}N$ egg mean. Within the latter two models, $\delta^{15}N$ egg mean and the interaction of $\delta^{13}C$ egg mean and $\delta^{15}N$ egg mean were significant terms. These data are potentially useful as metrics to assess effects of different foraging locations and (for $\delta^{15}N$) influences of trophic position. While only a baseline, this suggests that foraging location may be a potential driver of lipid content within unhatched, undeveloped eggs. If lipid content is a significant factor influencing hatchling quality and survival, then variation in this egg component has direct implications for species management, and emphasizes why protecting foraging areas is so important for the conservation of this species.

MONITORING EFFORTS FOR HAWKSBILL SEA TURTLE (*ERETMOCHELYS IMBRICATA*) ON HAWAII ISLAND, HI FROM 1989-2016

Lauren E. Kurpita[1], Catherine M. Herr[1], Elizabeth M. Ransom[1]

[1]*Hawaii Island Hawksbill Turtle Recovery Project, Hawaii National Park, HI, USA*

The Hawaii Island Hawksbill Turtle Recovery Project was founded in 1989 and monitoring for nesting hawksbill sea turtles (*Eretmochelys imbricata*) was limited to the boundaries of Hawaii Volcanoes National Park. Over time monitoring efforts expanded across the Southern portion of Hawaii Island and now includes nesting beaches owned by Federal, State, County, and private entities. Monitoring was provided through volunteer efforts via hiking or on four-wheeled drive access roads to remote nesting locations. Data was collected through night monitoring and day checks to look for signs of nesting activity. Tagging of nesting females began in 1991 and 150 individuals have been documented. The project has recorded 1,027 nests and 114,741 hatchlings have reached the ocean. Baseline data collected included (1) the mean clutch size was 173 ± 36.9 eggs (n=873) with a range of 66 to 293 eggs; (2) the mean incubation period was 62 ± 6.2 days (n=547) with a range of 50 to 79 days; (3) the mean hatch success was 72% ± 26% (n=890) with a range of 0% to 100%; (4) the mean nest-to-nest inter-nesting interval was 20 ± 3.0 days (n=356) with a range of 13 to 30 days; (5) remigration intervals were 4 ± 2.3 years (n=177) with a range of 2 to 14 years. Even though this monitoring effort has occurred for 28 nesting seasons, more monitoring efforts are needed to continue learning about this population nesting on Hawaii Island.

EVALUATING THE IMPACT OF METABOLIC HEATING ON SEX DETERMINATION OF THE HAWKSBILL SEA TURTLE

Jennifer Layton[1], Cynthia J. Lagueux[2], Cathi L. Campbell[2], Taylor Roberge[3], Nicholas Bolin[3], Thane Wibbels[3]

[1]*Samford University, Birmgingham, AL, USA*
[2]*Archie Carr Center for Sea Turtle Research, University of FL, Gainesville, FL, USA*
[3]*University of Alabama at Birmingham, AL, USA*

Sea turtles have temperature-dependent sex determination in which incubation temperature during the middle third of embryonic development determines sex. Previous studies have used both nest temperatures and/or beach temperature to predict hatchling sex ratios on beaches. Metabolic heating in nests is known to occur during the latter two thirds of development and could affect the thermosensitive period o embryonic development. It is unknown to what extent metabolic heating may affect sex determination;

therefore, predicting sex ratios using beach temperature alone may result in inaccuracies. The current study evaluated the impact of metabolic heating on incubation temperatures in nests of the hawksbill sea turtle (*Eretmochelys imbricata*) on the Pearl Cays, Nicaragua. Data loggers were used to monitor temperatures in the middle of the clutch in 19 natural nests. Additionally, a datalogger was placed at mid nest depth one meter from each nest to monitor the sand temperature adjacent to the nest. The middle third of development for was determined with the R package "embryogrowth" using nest incubation temperatures, nest incubation durations, and average size of a hawksbill hatchling. Nest incubation temperatures during the middle third of development were then used to predict the hatching sex ratio for each nest using the embryogrowth R package. Additionally, the temperatures adjacent to the nests were used to simulate nests that would not be impacted by metabolic heating. Comparisons of the predicted sex ratios of natural nests to the simulated nests indicated that metabolic heating was impacting the middle third of development. Further, depending on the specific incubation temperatures, metabolic heating could significantly impac hatchling sex ratio. The results have implications for field studies that are prediction hatchling sex ratio based on sand and/or nest temperatures.

COMPARISON OF THE BEHAVIOR AND MORPHOLOGY CHARACTERS OF THE HATCHLING GREEN TURTLES (*CHELONIA MYDAS*) AMONG THREE ROOKERIES, LANYU, LIUQIU AND WAN-AN ISLANDS

Chun Hung Lin[1], I-Jiunn Cheng[1]

[1]*National Taiwan Ocean University*

Recent studies found that incubation environment can influence morphological characters and behavior of sea turtle hatchlings. In Taiwan, there are three major nesting sites; Wan-an Island, Lanyu Island and Liuqiu Island. Geographical location and environment vary from one island to the others. Thus, we would like to determine how the nesting environment influence the behavior and morphological characters of hatchlings among the three islands. We measured straight carapace length, curve carapace length, flippers length, body weight, swimming and crawling speeds as well as self-righting ability of the hatchlings. Results showed that the flippers length was longer in Wan-an and Lanyu rookeries than Liuqiu rookery. The hatchlings from Wan-an rookery had the longest carapace length and were the heaviest among three rookeries, followed by Lanyu rookery; and Liuqiu rookery. However, the hatchlings from Lanyu rookery crawl and swim faster than hatchlings from Wan-an and Liuqiu rookeries. The hatchlings from Liuqiu rookery had greater self-righting ability than Wan-an and Lanyu rookeries. There was a negative relationship between flippers length and crawling speed of the hatchlings from Lanyu and Wan-an rookeries. There was also a negative relationship between carapace length and swimming speed of the hatchlings in Wan-an rookery. The locomotion behavior, however, was not related to the size of hatchlings. This might relate to the fact that the hatchlings from Lanyu rookery had stronger locomotion ability than the other two rookeries, even though they are smaller in size. The differences in morphological characters and behavior might relate to the predation pressure and marine environment they encountered after the emergence from the nests.

THE IMPACT OF MOISTURE ON NEST CONDITIONS AND HATCHLING SEX RATIOS

Alexandra Lolavar[1], Jeanette Wyneken[1]

[1]*Florida Atlantic University*

Sex determination in sea turtles is heavily dependent on the surrounding environment during incubation; however, the specific mechanism behind this process remains unclear. While many biologists are confident of temperature's role in sex differentiation, the impact of other factors such as moisture remains unclear. Whether increased moisture directly affects sex determination or through nest cooling also continues to be in question. It also remains unclear how rainfall impacts the interactions of other environmental factors in the nest, such as nest temperature and sand moisture. This study examined the impact of increased moisture on such factors, as well as the effect on hatchling sex ratios. Environmental factors are seldom examined in the field (natural nests) in a controlled way. This study did not attempt to isolate any one individual factor, but rather examined the relationship between nest temperature and sand moisture and compared these factors between control nests (not watered) and experimental nests (watered). This study also investigated how the combination of these factors may influence hatchling sex ratios. Eighteen loggerhead (*Caretta caretta*) nests were relocated and divided into two smaller nests: a control group and an experimental group. We placed the experimental group in close proximity to sprinklers from a local condominium. Each nest contained a soil moisture probe and temperature datalogger to measure sand moisture content and nest temperature throughout incubation. A sample of hatchlings from each nest was collected and raised in the lab and their sex was verified. We identified correlations between nest moisture events (rainfall as well as nest watering) and nest conditions and compared sex ratios between control and experimental groups. Nest temperatures and nest sand moisture content differed between control and experimental groups. Watered nests from the experimental group had overall lower nest temperatures and higher moisture content. Despite differences in temperature and moisture content between groups, both groups had strongly female-biased sex ratios. This may be explained by extremely warm temperatures, which characterized the 2016 nesting season. Thus, control and experimental groups differed in temperature, but temperatures in both groups remained too high to produce males. The water treatments in this study aimed to mimic the impact of daily rainfall. A greater understanding of the effects of rainfall will allow for a better understanding of hatchling sex ratios. By mimicking rainfall events, we will obtain more knowledge concerning the role of rainfall and the potential effect of increased rainfall events. It is particularly interesting to study the effects of increased moisture by rainfall in years with exceedingly high temperatures. This information will increase our understanding of the variation in, and drivers of, natural sex ratios.

REPRODUCTIVE ECOLOGY OF OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS CORIACEA*) FROM A NON-ARRIBADA NESTING POPULATION NEAR ZIHUATANEJO, GUERRERO, MEXICO

Damaris Marin-Smith[1], Marlet A. Luna[1], Felipe C. Crispin[1], Gene Smith[1], Andrew T. Coleman[1], Alan Rodriguez[1], Jorge Felix[1], Jesus Abeldano[1], Fernando Lopez[1], Angelica CS Alicia[1], Tanya Lopez[1], Ma. Jesus Montor[1], J. Enrique Marin[1]

[1]*Campamento Tortuguero A.C*

Campamento Tortuguero Ayotlcalli is a community-based sea turtle conservation group that has been monitoring a series of nesting beaches located near Zihuatanejo, Guerrero, Mexico, since 2011. The main species that nests on these beaches is the olive ridley sea turtle (*Lepidochelys olivacea*) (818 observed nests during the 2015-2016 season), but a few nests of leatherback (*Dermochelys coriacea*) and green (*Chelonia mydas agazissi*) are documented each year. This olive ridley population displays a non-arribada nesting strategy, and the nesting season generally extends from July to February, with the highest amounts occurring from August to October. A markrecapture study was initiated in 2015, and 179 olive ridley females have been tagged thus far. Tagging will allow an estimation of intra- and interannual nesting frequency, which will provide insight into the size of this nesting population and the degree of site fidelity. The mean curved carapace length and mean curved carapace width for nesting females were 64.08 ± 3.15 cm and 68.62 ± 3.55 cm, respectively. The mean clutch size was 89.33 ± 19.73 eggs, with a maximum observed clutch size of 137 eggs. Poaching of nests and nesting females represents a major threat on these beaches, so observed nests are relocated to an egg corral. Annual hatching success rates have ranged from 58.1% (2014–2015) to 96.4% (2012–2013), but the mean hatching success rate from 2012–2016 was 77.77% ± 13.24%. Based on the number of observed olive ridley nests, the nesting beaches in th Zihuatanejo area may support an important solitary nesting population of olive ridley sea turtles for this region of Mexico.

LOGGERHEAD AND GREEN TURTLE REPRODUCTIVE SUCCESS ON A MIXED-USE BEACH: AN 11-YEAR COMPARATIVE ANALYSIS OF CONTRIBUTING FACTORS*

Rebekah Lindborg[1], Emily Neidhardt[1], Blair Witherington[1], J. Rachel Smith[1], Anne Savage[1]

[1]*Disney's Animals, Science and Environment*

Although estimates of sea turtle reproductive success are important to quantify population status and effects from threats, published representative values of these rates are rare. Most assessments involving hatching success have taken place as part of experimental analyses that did not spatiotemporally represent a population. To fill this gap, we analyzed an 11-year time series (2004—2014) of sea turtle hatching and emergence success data for a 7-km stretch of Florida (USA) beach backed by mixed suburban and resort/recreational land use. Our analysis examined potential egg-mortality factors associated with the incubation of these nests. The data set included representative sampling of loggerhead (*Caretta caretta*) nests (n = 2543, 34.4% of all nests made during the period), and green turtle (*Chelonia mydas*) nests (n = 972, 44.7% of all nests). Mean (± SD) annual hatching success was 68.6 ± 35.5% for loggerheads and 59.6 ± 39.5% for green turtles, and mean emergence success was 66.6 ± 35.7% for loggerheads and 57.0 ± 39.1% for green turtles. Mammalian predation rates had little effect on overall hatching success trends on our study beach with the sample of predation events (0.3% over 11 years) too small to analyze. There were

significant effects from tropical storms and hurricanes on hatching success trends throughout the study period, based on negative correlations between hatching success for each species and highest wave height incurred during incubation, mean wave height during incubation, and the number of days that study nests incurred 2 m or higher waves. Hatching and emergence success for each species were lowest during tropical cyclones, which corresponded with an increased number of complete nest wash-outs. Nests within our study site had higher hatching and emergence success rates compared to loggerhead and green turtle nests at other Florida beaches.

QUANTIFYING THE NEST MICROENVIRONMENT: IMPACTS OF AN INVASIVE PLANT ON HAWKSBILL SEA TURTLE HATCHING SUCCESS AND INCUBATION TEMPERATURE

Andrew S. Maurer[1,2], Seth P. Stapleton[2], Alexandra L. Fireman[2], Jillian Tucker[2], Craig A. Layman[1]

[1]Department of Applied Ecology, North Carolina State University. Raleigh, NC, USA
[2]Jumby Bay Hawksbill Project. Long Island, Antigua, West Indies

Sea turtle populations are faced with widespread environmental changes that affect their ecology in complex ways. For example, the rise in species invasions is generating novel interactions in both marine and terrestrial sea turtle habitats. On Long Island, Antigua, a thick and aggressively growing invasive beach shrub, *Scaevola taccada*, has become the dominant species of vegetation on a nesting beach for hawksbill sea turtles (*Eretmochelys imbricata*). Hawksbills tend to seek out vegetated nest sites, leading to frequent interactions with the human-introduced invasive. We hypothesized that *S. taccada* affects incubation temperature and hatching success through differences in plant structure and microenvironment (e.g. substrate moisture) compared to native plants. These potential interactions could have important implications, threatening reproductive output and affecting temperature-dependent sex determination. In 2015 and 2016 we sampled hawksbill nests associated with native vegetation, the invasive plant, or non-vegetated open sand. At all nest sites we measured microsite variables including: substrate moisture, substrate grain size distribution, substrate percent organic matter, distance to the edge of vegetation, distance to the high-water mark, percent overhead cover, vegetation structure, and elevation. We measured incubation temperature with a data logger placed into the center of the clutch during egg-laying, and estimated hatching success by excavating nest remains post-emergence. Using a multiple regression framework, we quantified the impact of *S. taccada* on incubation temperature and hatching success. More generally, we also estimated what microsite variables are most important for predicting incubation temperature and hatch success. Our results provide important empirical information in the context of ongoing environmental change, and can help inform beach management conducive to nesting hawksbills and their long-term conservation.

EVALUATION OF *LEPIDOCHELYS OLIVACEA* NEST TRANSPLANTATION DURING THREE LAYING SEASONS AT THE COASTLINE OF DEMOCRATIC REPUBLIC OF CONGO

Samuel Mbungu[1], Ndamba Marcel Collet[1]

[1]ACODES NGO, D.R..Congo

We want to show our colleagues working on marine turtles the effort we have just made to contribute to the conservation of marine turtles. ACODES is working in partnership with the ICCN at the Marine Park of the Mangroves on a 40 kilometer coastline. During each laying season, ACODES monitors four sites

that host about one hundred of the clutches of the *Lepidochelys olivacea* females mainly, and there are also some clutches of *Dermochelys coriacea*. The current configuration of the beaches does not leave enough chances for a good evolution of nests formed naturally. The waters of the waves raised by the high tides flood these nests and the eggs do not result in hatching. In order to contribute to the maintenance and conservation of turtles within our coastline, we implemented the egg transplant strategy, re-establishing nests on artificial hatcheries that ultimately lead to outbreaks for which the success rate Ceases to improve over time. ACODES would like to take advantage of this major international event on the biology and conservation of marine turtles to share this exciting experience with other researchers.

UNDERSTANDING FACTORS AFFECTING NESTING PATTERNS OF THREE SPECIES OF SEA TURTLES AROUND THE ISLAND OF BARBUDA (LESSER ANTILLES)

Wendy McFarlane[1], Maxine Montello[1], Melissa LaCroce[1], Nancy E. Todd[1]

[1]Department of Biology, Manhattanville College, Purchase, NY, USA

Numerous studies have correlated beach conditions to nesting success in various sea turtle species. On the island of Barbuda, there are significant differences across nesting beaches in terms of substrate, width and slope, and vegetation cover. This study sought to understand the physical characteristics of nesting sites of turtles around the island between 2010 and 2016. Over this monitoring period, the nesting areas were divided into eight beach sites, with six sites on the western and southern coastlines, and two along the eastern shoreline. Some sites were accessible only by boat, while others were surveyed on foot. Over the six years of sampling, hawksbill, green, and leatherback crawls leading to nest sites were documented and mapped using GIS (ArcMap 10.1). Morphometric analysis of crawls included identification of species, measurement of maximum width, and distance from high tide mark to the nesting site. Vegetation present at each beach site was identified and quantified along 50m transects to determine the vegetation diversity and coverage. Beach slope was calculated from photographic analysis, and distance from high tide mark to nest were compared across the beach sites as a measure of effort for females to traverse different beaches. Sand grain size and pH were measured from multiple sampling points at each beach site. Beach slope varied across sites by 10-fold, yet did not appear to deter nesting. Nor did beach width, as some of the most utilized areas had the broadest traverse from water's edge to nesting site. Beaches with high slope also had finer sand/lower grain size. However, the pH of the sand was very consistent for all sand types. It was clear that hawksbill, leatherbacks and green turtles utilized the western and southern shores of the island (Caribbean side) more frequently than the eastern shore (Atlantic side). We were able to correlate the western preference to beaches with a lower slope, smaller grain size, and more diverse vegetation cover. Furthermore, the lower energy coastline and freedom from physical obstacles (such as off shore reefs and marine debris) of the western and southern sides of the island likely played a significant role in nesting beach choice. Analysis of physical and vegetation conditions at potential nesting sites, and relative beach use by different turtle species will aid in the development of monitoring programs and conservation efforts to maintain Barbuda's nesting turtle populations. As the western and southern shores of the island are also the most heavily utilized by the island's tourist industry, the opportunity for ecotourism is considerable. Furthermore, any future plans for development on the island should be considered in light of this data.

LEATHERBACK, OLIVE RIDLEY AND GREEN TURTLE VOCALIZATIONS DURING DEVELOPMENT AND EMERGENCE COMPARED*

Lindsay McKenna[1], Nathan J. Robinson[1], Frank V. Paladino[1]

[1]*Indiana-Purdue University*

Many animals vocalize to communicate. While this vocal communication has been studied extensively in mammals and birds, far less attention has been paid to reptile vocalizations. Sea turtles vocalize in the nest, but the purpose of these vocalizations is unknown. We aimed to characterize the vocalizations of the olive ridley turtles (*Lepidochelys olivacea*) in the nest during incubation, hatching, and emerging. We also aimed to characterize and compare the vocalizations of olive ridley, leatherback (*Dermochelys coriacea*), and East Pacific green (*Chelonia mydas agassizii*) turtle hatchlings. We relocated three olive ridley nests at Parque Nacional Marino Las Baulas, Costa Rica, and buried them next to a plexiglass window, which was used to obtain video recordings using a Canon digital camera. A hollow tube leading from above the eggs to the sand's surface was used to insert an Earthworks M30 microphone that was attached to a Marantz PMD61 MKII recorder to record audio. Each recording was categorized as incubation, hatching, or emerging. 60 minutes of each stage was analyzed using Raven Pro sound analysis software. The type (harmonic, non-harmonic, pulse) and characteristics (highest frequency, dominant frequency, lowest frequency, duration, and frequency range) were documented. We also recorded olive ridley, leatherback, and East Pacific green hatchlings in buckets. The same characteristics of vocalizations were documented from the bucket recordings as the nest recordings. For statistical purposes, the Chi-Squared Test, Friedman Test, and Kruskal-Wallis tests were used. We recorded a total of 157 vocalizations from the nests. The frequency of the vocalizations ranged from 0.05 - 11.4 kilohertz and the duration ranged from 0.01 - 0.54 seconds. We found significantly more vocalizations in the incubation stage than the other two stages ($p < 0.05$). The pulse vocalizations were only found in the incubation stage. Also, there was no significant difference seen in types or characteristics of vocalizations among the stages ($p > 0.05$, all cases). The bucket recordings revealed that the frequencies were not significantly different, but the duration of the leatherback hatchling vocalizations were significantly longer than the other two species ($p < 0.05$). The other characteristics of the vocalizations between species were not different. The olive ridleys hatchlings in the bucket vocalized more often than the hatchlings in the nest ($p < 0.05$). The frequencies in the bucket were within the same range as the frequencies in the nest, which was also seen when comparing the leatherbacks in the bucket to Ferrara et al. (2014). The results suggest that the number of vocalizations or the pulse vocalizations could possibly be used in synchronizing hatching. The significance of the frequencies of the vocalizations in the nest is unable to be determined from this study. The similar frequencies of vocalizations among the three species suggest that all sea turtle species vocalize within the same frequency range both in the nest and in other situations such as a bucket. Elucidating the importance of vocalizations in hatchlings can help develop more conservation plans to ensure development and other noise pollution isn't interfering with any vocal communication.

USING 30 YEARS OF NESTING DATA TO INVESTIGATE CONSERVATION EFFORT SUCCESS ON BALD HEAD ISLAND, NORTH CAROLINA

Brooke Milligan[1], Emily E. Hardin[1], Chris Shank[1]

[1]*Bald Head Island Conservancy, Bald Head Island, NC, USA*

Bald Head Island (BHI), located in southeastern North Carolina, is a prominent nesting site for loggerhead sea turtles (*Caretta caretta*). In 1983, nightly beach patrols were initiated by the Bald Head Island Conservancy (BHI Conservancy), a 501(c)3 organization dedicated to barrier island conservation, education, and preservation. Long life spans and late sexual maturation of sea turtles make it difficult to gauge the status of populations and the effectiveness of conservation efforts. Data collected for >30 years by BHI Conservancy scientists provide a unique opportunity to investigate nesting patterns of BHI's loggerhead turtles. The number of nests per year has varied considerably, ranging from a minimum of 37 (2014) to a maximum of 197 (1987), with a slight decreasing trend (p<0.05). Poor nest site selection by nesting mothers (e.g. sites too close to the scarp or the high tide line) often resulted in nest relocation by BHI Conservancy staff. The number of nests requiring relocation has also fluctuated greatly, with relocation required for 35 ± 25% of total nests laid. Since 1986, Conservancy staff members have been able to observe approximately 80% of all nesting females during nightly patrols and tag any new females (flipper tags began in 1991 and PIT tags added to process in 2002). Based on tag information, BHI averages 31 ± 11 individual females per season, ranging from a minimum of 13 in 2009 to 58 in 1994. Previously untagged, or 'new,' mothers represent 64 ± 12% of the nesting turtle population each season. Egg incubation times have shown a slight downward trend from an average of 68 days in 1980 to 52 days in 2016 (R2=0.64), which correlates with an increasing trend in average summer temperature, months May through September ($p<0.05$). Hatching success has remained relatively steady over time with an average of 70 ± 15% of incubated eggs producing hatchlings. Hatching success did not differ significantly between in-situ and relocated nests (p>0.5) suggesting that by relocating nests which would have otherwise been lost the BHI Conservancy is augmenting the average annual hatching success. The combined influences of a high percentage of new nesting mothers each summer, a steady hatching success rate, and the relocation and protection of vulnerable nests by BHI Conservancy staff suggest that BHI's coastal habitat will continue to support a healthy nesting loggerhead population in the future.

IDENTIFYING NESTING PATTERNS OF THREE SPECIES OF SEA TURTLES ON THE ISLAND OF BARBUDA (LESSER ANTILLES) THROUGH USE OF GIS MAPPING TECHNIQUES

Maxine Montello[1], Wendy McFarlane[1], Melissa LaCroce[1], Nancy E. Todd[1]

[1]*Department of Biology, Manhattanville College. Purchase, NY, USA*

Around the islands of Antigua and Barbuda there are four species of sea turtles that have been identified. Of these, hawksbills (*Eretmochelys imbricata*), leatherbacks (*Dermochelys coriacea*), and green (*Chelonia mydas*) sea turtles nest on the island of Barbuda. Loggerheads (*Caretta caretta*) have been seen feeding here, but nesting activity has not been documented. The purpose of this study was to use GIS mapping techniques to determine which areas of the island of Barbuda were being utilized by nesting turtles, which species were nesting, and to identify trends in beach site selection over six nesting seasons, between 2010 and 2016. Eight beach sites were surveyed on the island, yearly. At each site, crawls that led to nesting

areas were mapped using GPS coordinates. Application of geographic information system (GIS) was possible after obtaining shape files to create the map of Barbuda (ArcMap 10.1). GPS coordinates were imported to illustrate frequency and position of nesting females around the island. Hawksbills were noted at all beach sites, yet each of the three species of turtle showed a preference to particular areas of the island. There were also year-to-year trends in site utilization around the island, suggesting that while one area may be more heavily utilized in a particular breeding season, all sites around the island are important over multiple breeding seasons. This is the first comprehensive, multi-year study to map nesting populations of sea turtles on this island. Due to its underdeveloped state, Barbuda is currently an ideal nesting habitat for hawksbills, greens, and leatherbacks. Given that this study shows entire perimeter nesting activity, greater conservation efforts are now needed to preserve the entire island as a nesting sanctuary.

RELATIONSHIP BETWEEN THE INCUBATION LENGTH AND THE SEX RATIO IN SEA TURTLES *LEPIDOCHELYS OLIVACEA* IN THE MONTERRICO MULTIPURPOSE NATURAL RESERVE (RNUMM), GUATEMALA*

Alejandra Morales-Merida[1,2,3], Dulce María Bustamante Zamora[1], Claudio Mendez[1], Marc Girondot[3]

[1]Escuela de Biologí-a, Facultad de Ciencias Quí-micas y Farmacia, Universidad de San Carlos de Guatemala. Guatemala
[2]Centro de Datos para la Conservación, Centro de Estudios Conservacionistas, Facultad de Ciencias Químicas y Farmacia, Universidad de San Carlos de Guatemala, Guatemala
[3]Laboratoire Écologie, Systématique, Évolution. Université Paris-Sud CNRS, AgroParisTech, Université Paris-Saclay, 91405 Orsay, France.

Sea turtles are known for having Temperature-dependent Sex Determination (TSD). The sex is determined during the second third of the embryo development, a period called Thermosensitive Period (TSP). Knowledge of sex ratio produced in different situation could help to mitigate the effect of climate change. Furthermore, conservation strategy in Guatemala involved artificial incubation in hatcheries of nearly 100% of the nests deposited on the beach. Thus, it is important to check that sex ratio produced by hatcheries are similar to sex ratio produced naturally. The golden method to establish sex ratio is histology but this technic is lethal and cannot be done at large scale for protected species. To circumvent this difficulty, it has been proposed to use the incubation length as a proxy of the thermal environment experienced by eggs during development. However, the relationship between incubation durations and constant incubation temperatures was significantly different for Olive Ridleys originated from Mexico and Costa Rica, both in the Pacific coast (Morales Merida et al. 2015). Thus, it was necessary to know if Olive Ridleys from Guatemala, between the Mexican and the Costa Rican populations, are more similar to the one or the other population for thermal sensitivity. The classical way to establish the thermal reaction norm for embryo growth necessitate incubation at different constant temperatures which is logistically unfeasible in many countries. We develop an alternative method using nests incubated in natural condition at changing temperatures. We incubated Lepidochelys olivacea eggs in 80 nests: 40 in an experimental enclosure design exclusively for this study (experiment) and 40 in the hatchery of the Monterrico Multipurpose Natural Reserve (RNUMM), in their regular management condition. To generate variation, the treatments of the experiment were made in a combination of shade and depths. The nests were submitted to 5 treatments: (1) under shade at 40cm; (2) under shade at 60 cm; (3) direct sun exposure at 40 cm; (4) direct sun exposure at 60cm; and (5) hatchery. For each nest we measure temperature each hour, incubation length, sex ratio, and hatching success of each nest. The experimental design allowed the generation of variation of the temperature and of the incubation length between the nests. We observed that both the sun exposure and the depth affected the temperature in the nests and the incubation length. From these incubation data, the

thermal reaction norm for embryo growth of Olive Ridleys from Guatemala has been established and compared with the one from Costa Rica and Mexico populations. Nevertheless, when dissecting 10 hatchlings for each of these 80 nests it was determined that all of the specimens were females. It is necessary to produce more evidence, using other hatcheries and natural nests, and promoting studies that evaluate the possibility of annual and regional variations in the sex ratio for this species.

MICROBIOTIC DIVERSITY IN THE SAND OF FOURTEEN FLORIDA SEA TURTLE NESTING BEACHES

Mario Mota[1], Gregory Heidel[1], Garett Huffstutler[1], Brian Arko[1], Nicole Salazar[1], Richard Cale[1]

[1]National University

Sea turtles nest throughout the world's beaches and the fate of their clutches depends on many factors including the biotic and abiotic properties of the sand. It is well documented how a multitude of sand properties can impact the nest microenvironment and consequentially have a positive or negative effect on incubation. The present study looks at the microbiotic diversity in the sand of fourteen sea turtle nesting beaches to document species presence and extrapolate the potential role they have on their respective microbiomes. This survey was conducted during the summer nesting season. All beach samples were collected during the same week except for Venice Beach where samples were collected at four locations every week from July until October. The former documents the diversity of bacteria throughout Florida's sea turtle nesting beaches, while latter documents changes within the same beach and nesting site. Samples were also collected along the dune and high tide line and at three different depths in the same location to document microbiotic differences across and at different depths of the beach planform, respectively. Sargassum and other macroalgae were collected at random locations and its bacterial fauna identified to see if they could serve as possible bacterial sources for beach sand. Sand samples were incubated in trypic soy broth and then plated in agar that selected for gram positive and negative bacteria. After individual bacterial colonies were isolated, its DNA was extracted using standard procedures. The 16s ribosome was target with a primer, DNA was amplified using a PCR, and the DNA was sent for sequencing. Bacteria species were identified by comparing their DNA sequences against several online databases such as BLAST. Data collected from several biochemical tests (oxidase test, glucose/fructose/lactose fermentation, anaerobic test, MacConkey and Mannitol Salt media, etc) done prior to DNA isolation were used to confirm the bacteria species identified by the database. Our results show that there is diversity in bacterial fauna in the sand samples from the fourteen Florida sea turtle nesting beaches. This diversity can be documented in relation to geography and sand properties. Several species of bacteria can also be related to anthropogenic sources, such as beach usage, drainage outfalls, proximity to homes and dog beaches. Although some bacteria species were found more prevalent in sand from hatched or unhatched clutches we cannot, at this time, state they played a significant role in the fate of the clutch. Further research is needed to test the direct influence these species have on the incubation of sea turtle eggs.

EFFECTS OF MATERNAL ORIGIN, MORPHOLOGY AND INCUBATION TEMPERATURE ON THE SWIMMING PERFORMANCE OF OLIVE RIDLEY TURTLE (*LEPIDOCHELYS OLIVACEA*) HATCHLINGS

Miriam S. Mueller[1], F. Alberto Abreu-Grobois[2]

[1]Posgrado en Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, México
[2]Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Unidad Académica Mazatlán, Sinaloa, México

Since marine turtle eggs incubate with no parental care, hatchling survival depends on favorable environmental conditions allowing for viable embryo development and on the hatchling's locomotor capacity to avoid predation while crawling from the beach to the sea, and when swimming into the open ocean. Successful incubation of eggs is restricted to a relatively narrow thermal regime, with optimal conditions in the middle of the temperature range. The olive ridley turtle nesting season in Sinaloa, Mexico, is relatively long: spanning the summer months and extending into autumn and part of the winter. During the peak of summer and at the end of the season, beach temperatures extend into the species' upper and lower thermal limits (respectively) often reaching lethal conditions. Incubations at the extreme thermal limits even within the tolerance range can have a negative effect on morphological traits that could affect fitness of the resulting hatchlings. Nonetheless, maternal origin of eggs also contributes and the effects are commonly confounded with incubation conditions. In order to evaluate the influence of incubation temperature, hatchling morphology and maternal origin on swimming performance of olive ridley hatchlings, we incubated eggs under controlled thermal conditions at three different incubation temperatures (27, 30 and 33°C) using a split-clutch approach. Swimming tests were conducted in DIY closed-circuit aquariums with continuous water flow and under dark to reproduce natural conditions. Swimming performance was video recorded with commercial surveillance equipment and data was evaluated using an open-source auto-tracking software for calculating distance travelled, swimming speed and swimming time among other parameters that allowed comparisons of individual's performance. Preliminary results show that incubation temperature and maternal origin influenced swimming performance, with temperature having the greatest effects. The results highlight the need for careful temperature management in nest conservation. In addition, they can help to generate criteria to test the swimming capacity as a proxy for fitness of offspring and identify conditions that make hatchlings more suitable and more resilient to face the consequences of climate change.

NOVEL METHOD FOR EVALUATING WATER STRESSORS AND THEIR EFFECTS ON SEA TURTLE EGG MORTALITY*

Emily Neidhardt[1], Rebekah Lindborg[1], Blair Witherington[1], J. Rachel Smith[1], Anne Savage[1]

[1]Disney's Animal Kingdom

Water events such as tidal over-wash, groundwater inundation, and excessive rainfall have been shown to inhibit development of embryos and successful hatching of sea turtle nests. Tidal over-wash can reduce hatching and emergence success through sand erosion or accretion, and drowning of eggs from inundation. Although monitoring tidal over-wash is most commonly accomplished through human observation, this technique requires extensive effort and represents only surface effects. We propose a novel technique for recording water stress events within sea turtle nests, specifically over-wash and rainfall, using temperature

data loggers as constant sentinels. Our study took place on a 7 km beach monitored for sea turtle nesting by Disney's Animals, Science, and Environment team in 2015-2016. We conducted week-long trials with three sets of six HOBO TidbiT v2 temperature data loggers. One set of data loggers was buried in high beach, mid-beach, and low-beach environments at 10 cm depth intervals. The temperature plots from this period (no rainfall recorded) served as a control throughout the experiment. In these temperature plots, we identified acute variation from natural diurnal heating and cooling patterns, and defined these signals as evidence of disturbance from rain or tidal over-wash. In experimental loggerhead nests left in situ (N=54), we deployed two data loggers per nest immediately following oviposition. One data logger rested on the top of the clutch and the other at the bottom, anchored under the clutch. We retrieved data loggers and all unhatched eggs at excavation (three days after hatchling emergence or 70 days after oviposition if no emergence was observed). Temperature plots were analyzed, and the water stress signals for each nest were assigned an index (time duration x number of data loggers affected). Water-stress events apparent in the plots were compared with human observations and precipitation data. We dissected unhatched eggs from each sample nest to determine embryo stage at developmental arrest. We plotted stage-specific water stress indices against stage-specific mortality to determine critical effects from water events. Our preliminary results suggest that early and late-stage embryos are most susceptible to water stress. We conclude that using temperature data loggers in sea turtle nests to measure abiotic stressors may reduce daily effort for monitoring programs by effectively recording water events in the nest. We also found that this nest-monitoring technique can be used to determine timing and frequency of other nest events such as predation events and hatching.

THE IMPACT OF DYNAMIC SHORELINES ON THE REPRODUCTIVE ECOLOGY OF SEA TURTLES: A CASE STUDY OF *CARETTA CARETTA* IN SOUTHWEST FLORIDA, USA

Sarah Norris[1], Dave Addison[2], Jill Schmid[3], Phil Allman[1]

[1]FGCU Dept of Marine and Ecological Sciences, Fort Myers, FL, USA
[2]The Conservancy of Southwest Florida, Naples, FL, USA
[3]Rookery Bay National Estuarine Research Reserve, Naples, FL, USA

Species that utilize dynamic systems are often faced with environmental changes that can impact the quality of habitat. Barrier islands represent one such system where storm events, wave action, beach erosion-accretion dynamics, and sea level fluctuations continuously alter the shoreline profile. These changes may impact the reproductive success and survivorship of threatened sea turtle species that utilize barrier islands for nesting habitat. Examining long-term sea turtle nesting data can give insight into how sea turtles respond to these habitat changes. In this study, we examined how nesting activity, nest site selection, and hatching success vary with shoreline changes on Keewaydin Island, Florida, USA from 1996-2015. The island has approximately 0.8 kilometers over this time period, as a result of erosion on the northern end of the island and accretion on the southern end. Nesting *Caretta caretta* are showing a trend of shifting nesting activity toward the northern portion of the island compared to the southern end, although there is no significant difference within each zone over time. The distance *C. caretta* are crawling above the mean high-water line to utilize for nesting strongly correlates with beach width (p < 0.0001). We will also present data indicating how the shift in nesting along the island is impacting hatchling emergence success. These data suggest rapidly increasing shoreline changes associated with global climate change may have far reaching consequences on sea turtle population dynamics.

IMPACT OF THE EL NIÑO PHENOMENON ON THE NEST SURVIVAL OF THE LEATHERBACK SEA TURTLE (*DERMOCHELYS CORIACEA*) AT PLAYA CHIRIQUI, CARIBBEAN COAST OF PANAMA

Cristina Ordoñez[1], Raúl García[1], Roldán A. Valverde[1]

[1]*Sea Turtle Conservancy*

In 2003 the Sea Turtle Conservancy (STC) started a sea turtle monitoring and research programme on the Caribbean coast of Panama in collaboration with local communities. Playa Chiriquí (Comarca Ngäbe-Bugle) was described as the most important Hawksbill (*Eretmochelys imbricata*) nesting site in the Caribbean (Carr 1956). Furthermore, with an average of 4,500 nests per season, this beach was also reported to be the most important nesting site for the Leatherback turtle (*Dermochelys coriacea*) in Central America (Ordoñez 2007). This study investigated potential relations between nest survival and hatching success and the El Niño phenomenon. El Niño is a recurring oceanic-atmospheric phenomenon in the eastern equatorial Pacific Ocean caused by a weakening of the trade winds. This weakening of trade winds causes warm water to move east and disrupt oceanic current patterns. This phenomenon, even though its origin lies in the Pacific Ocean, has an effect on a global scale. In the Caribbean this effect mainly shows as increased rainfall, which can trigger changes in terrestrial, marine and coastal ecosystems. In the case of sea turtle nesting beaches, the resulting consequences can be detrimental due to changes in beach morphology, which can lead to the loss of nests and/or impact their success due to erosion, flooding or increased groundwater levels. Survival and productivity of Leatherback sea turtle nests were analysed for the period between 2007 and 2016 in relation to the intensity of the El Niño phenomenon during the incubation months (March to September). Both seasons 2015 and 2016 showed a considerable increase in eroded and flooded nests (64% and 6%; 15% and 18%, respectively) that coincided with a very strong El Niño event that started in October 2014 and ended in June 2016. In 2009 an El Niño event of only medium intensity occurred that only manifested itself at the end of the incubation period (August 2009 - May 2010) and resulted in a lower number of eroded and flooded nests (1% and 12%). Effects of the El Niño phenomenon could also be observed in relation to hatching and emerging success of nests. In 2015 and 2016 hatching and emergence successes were lower (21.7% and 20.2%; 40.4% and 38.3%, respectively), compared to 2009 (63.5% and 57%, respectively). The preliminary results of these analyses showed that there exists a relation between nest survival and productivity and the El Niño phenomenon. However, it is important to bear in mind that there are other variables outside the current study that can affect the development of nests, such as tropical storms. Existing weather forecast programmes allow mitigating measures to avoid possible negative effects on sea turtle populations on nesting beaches that are at risk to be affected by the El Niño phenomenon.

POTENTIAL CHANGING ENVIRONMENTAL PARAMETERS MIGHT ALTER THE NESTING BEHAVIOUR OF LEATHERBACK TURTLES

Albert Palomino Gonzalez[1], Marga Lopez Rivas[2]

[1]*University of Alicante*
[2]*University of Granada*

Several studies have strongly suggested that climate change affects life history processes, such as breeding, which is in its turn most likely guided by climate. Sea turtle females wait offshore for the optimal conditions

to nest, but these environmental cues keep being mostly unknown. Our aim was to identify the factors that drive leatherback turtle (*Dermochelys coriacea*) nesting behaviour and try to find any specific conditions that induced turtles to abort nesting. To assess these issues, the beach in Pacuare Nature reserve, on the Caribbean Costa Rica, was monitored from 2010 to 2015. The GLMs offering the best goodness of fit showed positive correlation with high atmospheric pressure, thus favouring nesting; negative correlation with high rainfall, which is reflected in discouraging turtles from nesting; and high and low tides were negatively correlated with nesting, suggesting that turtles avoid nesting when tidal cycles reach their extremes. Differences between GLMs with nesting and aborted attempts as response variables were barometric pressure, which favours successful nesting; and rain, together with high and low tides, which adversely affected nesting. Overall, climatic features likely related to storm episodes such as heavy rainfall, change in wind patterns and extreme tidal ranges appear to influence leatherbacks' nesting behaviour. Therefore, the steady increase in intense storm occurrence predicted by climatic projections might represent an additional obstacle to the survival of this species.

FUNGUS AMONG-US: WHAT WE DO KNOW, WHAT WE DON'T KNOW, AND WHAT WE STILL NEED TO KNOW ABOUT MICROBES IN SEA TURTLE NESTS*

Andrea D. Phillott[1]

[1]*Asian University for Women*

Microbes in sea turtle nests and substrates have been the focus of both multi-year studies at rookeries in eastern Australia, Boa Vista Island (Cape Verde, Africa), and Ostional (Costa Rica), and individual reports world-wide. While microbes have been isolated from cloacal fluid collected during oviposition, the most likely source is the nest substrate. Embryo mortality has been attributed to both pathogenic and non-pathogenic mechanisms. In some nests, fortuitous egg mortality provides a nutrient source and focus for opportunistic invasion of the nest followed by the progressive spread of fungal hyphae to adjacent viable eggs; mortality may occur due to decreased respiratory surface area or eggshell calcium, or pathogenic invasion of embryonic tissue. Beaches with high density nesting and resulting high organic matter content may develop environmental conditions in which the partial pressure of oxygen and nest temperature are beyond the optimal range for embryonic development. This presentation identifies areas of priority for future study and emerging technologies in microbial ecology to help sea turtle biologists and conservationists better understand the potential impact of microbes in sea turtle nests and substrates on the success of individual nests, nesting beaches, and nesting populations.

PATOK SEA TURTLE RESEARCH AND FIRST AID CENTER: THE FIRST OF ITS KIND ESTABLISHED IN ALBANIA

Vilma Piroli[1], **Idriz Haxhiiu**[1]

[1]*Herpetofauna Albanian Society, Tirana, Albania*

Patok Sea Turtle Research and First Aid Center is the first sea turtle center in Albania. It was established in 2016 by the NETCET project, an international project co-financed by the IPA CBC Adriatic Programme, and implemented during 2012-2016 in the Adriatic region by 13 partners from Albania, Croatia, Italy, Montenegro and Slovenia. The center is an environmentally friendly building inside the Patoku Lagoon, a key area near the Drini bay where the bycatch and presence of foraging turtles is so high. The center is

designed for both preservation and conservation. There is a meeting room where education, training, information of the public, and dissemination of data to the scientific community could occur, and a laboratory equipped with 2 tanks and the necessary equipment for providing first aid to injured turtles, investigations about reasons of death and diseases, and scientific research. A total of 25 loggerhead turtles (*Caretta caretta*), mainly collected from Drini bay, were hospitalized and provided with the first aid during the operation period of this center (February2016 - February 2017), while other 222 were studied. Upon arrival at the centre, the injured turtles were measured and scored by body conditions. The main causes of injuries and medical problems were found to be related to parasites (n=16) and interactions with human activities (n=9). The turtles with wounds after being assessed for the extent of the damage, were disinfected, freed by debris and kept in tanks with no water to avoid contamination. The turtles with parasites like leeches were kept in tanks with fresh water for 12-24 hours for parasite removal. Human activity impact on turtles consists of propeller cuts from boats and boat crashes on carapace, head or beak (n=4), fishing line cuts (n=2), fishing hook or net ingestion (n=3). This center, as the very first one of its kind in Albania, has a key role in the management and implementation of the action plan, and gives the necessary input to the Albanian legislative activities to improve the conservation and preservation of these species. The ongoing effort to increase public awareness and provide first aid to the damaged turtles, made possible by this centre, is crucial to the survival of the sea turtles in our area. The experience of the first year highlights the importance of expanding the activity of this centre from first aid to a rescue centre.

COMPARING THE EFFECT OF TEMPERATURE ON THE DURATION OF THE INTERESTING INTERVAL ACROSS MULTIPLE SEA TURTLE SPECIES*

Nathan J. Robinson[1], Gabriela Blanco[2], Chelsea Clyde-Brockway[1], Jacob E. Hill[3], Samir H. Patel[4], Aliki Panagapoulou[5], Pilar Santidrián-Tomillo[6], George S. Shillinger[5], Cassondra Williams[7], James R. Spotila[8], Frank V. Paladino[1]

[1]*Indiana-Purdue University Fort Wayne*
[2]*CONICET*
[3]*University of Mississippi*
[4]*Coonamessett Farm*
[5]*The Leatherback Trust*
[6]*IMEDEA*
The Leatherback Trust
[7]*University of California: San Diego*
[8]*Drexel University*

Sea turtles often exhibit dramatic responses, both behavioural and physiological, to variations in external temperature. For example, previous studies have shown that external temperature is strongly correlated to the duration of inter-nesting period in both loggerhead *Caretta caretta* and green *Chelonia mydas* turtles. Specifically, as temperatures increase the duration of the inter-nesting interval decreases, presumably because the rate of pre-ovipostional eggs development is increased at higher temperatures. Yet, uniquely among sea turtles, the leatherback *Dermochelys coriacea* is able to maintain body temperatures significantly elevated about external conditions though gigantothermy. As such, we predict the duration of the inter-nesting interval in leatherback turtles would not be affected by variation in water temperature as it is with other sea turtle species. To test this, we deployed data-loggers, with the capacity to record temperature at intervals less than 1 min, between 2002 and 2013 onto inter-nesting leatherback (n = 42), green (n = 9), and hawksbill (n = 7) turtles *Eretmochelys imbricata*. As expected, higher temperatures lead to shorter inter-nesting intervals in green, and hawksbill turtles, but not for leatherback turtles. Interestingly, this means that under warmer conditions, non-leatherback sea turtles have shorter inter-

nesting intervals and thus remain at the nesting location for shorter periods of time. In contrast, leatherback turtles remain in nesting habitats for similar lengths of time regardless of temperatures. This has implications for how nesting phenology will vary between sea turtle species in response to climate change and explains why local temperature variation has not been linked to nesting phenology in leatherback turtles as it has in the other sea turtle species.

RELATIVE PERIOD OF TEMPERATURE SENSITIVITY IS DEPENDENT UPON SPECIFIC INCUBATION TEMPERATURES

Taylor Roberge[1], Thane Wibbels[1]

[1]*University of Alabama at Birmingham*

Many reptiles, including sea turtles, exhibit temperature-dependent sex determination (TSD), a form of sex determination in which incubation temperature during the temperature sensitive period (TSP) determines sex. Previous incubation studies have determined the TSP coincides with the approximate middle third of embryonic development. The majority of these studies used constant temperature incubation with a shift to a single temperature during the middle third of incubation to determine the period of temperature sensitivity. There is some evidence that the incubation temperature before the shift may influence the duration of the TSP with cooler temperatures lengthening it. Additionally, a larger magnitude shift near the end of the TSP can result in greater abundance of sex reversal. It is currently unknown whether the TSP under fluctuating incubation temperatures behaves in a similar pattern seen in constant temperature studies or whether large magnitude shifts near the end of the TSP could extend the relative period of temperature sensitivity. In this study, we examined the effects of multiple temperature shift magnitudes as well as the effects of fluctuating incubation temperature on the end stages of the TSP in a model TSD species, *Trachemys scripta*. TSD in this species has a similar pattern and pivotal temperature to many sea turtles. Eggs were placed under three treatment temperatures: 1) Constant 31°C, 2) 26°C ± 3°C, and 3) 31°C ± 3°C. Eggs were dissected frequently to determine the stage of the embryo and eggs were shifted to incubators with temperatures known to produce the opposite sex at stages before, during, and after the previously reported end of TSP. Eggs were then allowed to incubate until just before hatch and were then sexed. Similar to previous studies at constant temperature, incubation temperature affected the length of the TSP with cooler temperatures extending the number of developmental stages sensitive to temperature. Additionally, 3°C fluctuations did not seem to affect the end of the TSP compared to constant temperature incubation with the same mean. The magnitude of the shift changed the amount of sex reversal suggesting a temperature potency affect. The results of this study have implications in both the physiology of TSD as well as conservational implications when trying to model sex ratios by comparing field data to controlled laboratory studies.

TEMPORAL AND SPATIAL THERMAL VARIATION IN AN OLIVE RIDLEY NESTING BEACH IN SOUTHERN SINALOA, MEXICO PROVIDES INSIGHT ON POTENTIAL IMPACTS BY LETHAL TEMPERATURES

Yazmin Segura García[1], Raquel Briseño-Dueñas[2], F. Alberto Abreu-Grobois[3]

[1]Posgrado en Ciencias del Mar y Limnología - Universidad Nacional Autónoma de México - Unidad Académica Mazatlán
[2]Banco de Información de Tortugas Marinas - Universidad Nacional Autónoma de México - Instituto de Ciencias del Mar y Limnología - Unidad Académica Mazatlán
[3]Laboratorio de Genética - Universidad Nacional Autónoma de Mexico - Instituto de Ciencias del Mar y Limnología - Unidad Académica Mazatlán

While a long-term goal of sea turtle conservation programs is to return nest incubation to nature once predation and poaching are controlled, this is only acceptable if suitable conditions are guaranteed. With increasing temperatures, a key question is whether or not the thermal conditions in the natural environment are viable for incubation. At our Las Cabras nesting beach in southern Sinaloa, where nests need to be relocated to protected hatcheries to survive, a monitoring program using temperature loggers at nest depth in representative parts of the beach has been implemented to understand temporal and spatial variation along the 12 km beach where about 450-630 olive ridley nests are laid per year. Results from experimental nests show that hatching rates decline when average temperatures are below or above 28-30°C, and are zero above 34°C or below 26°C. While the effect in the upper range is congruent with findings in other studies, mortality due to the lower range of field temperature is less well known but extremely relevant to this species since its nesting season extends into winter and early spring. Strong spatial variations are present not only in nesting density but also in sand temperature and grain composition. The northern end of the monitored beach tends to concentrate the majority of nests, has a higher temperature at nest-depth (on average 0.7°C higher) and a greater proportion of the smallest (<0.13 mm) and darkest grains. In order to investigate levels of mortality from thermal stress if nests were left in the beach, we derived a model for the relationship between incubation temperature and hatching percentage from experimental nests. We then used it to extrapolate levels of temperature-related embryo mortality in nests if they had been left in situ, taking into consideration the geolocations of nests laid during 2013-2016 and the spatial and temporal variation in temperature. The results suggest that over at least three months of the season (June-August) lethal incubation temperatures prevail which is alarming considering that the greatest nesting density (60% of the total) occurs over this period. Highest hatching rates are estimated for the cooler months (where nesting is lower) but additional mortality would be expected during the winter months when nesting still occurs. Thus, after weighing by temporal and spatial nesting abundances, a resulting yearly hatching rate of barely 15-26% was estimated due to temperature-related embryo mortality. The magnitude of the potential impact by currently stressful temperature conditions in the natural habitat can be appreciated if we contrast these values with the average 85% hatching rate obtained in the hatcheries where shading is implemented. These results highlight the need to monitor the temporal and special distribution of temperatures and how the effect of heat stress interacts with changes in nesting abundances to gain realistic insights on the magnitude of the impacts. Nonetheless, while successful conservation of sea turtle is complex and requires a comprehensive understanding of multiple factors which may differ among sites, in our region at least, incorporating methods to control solar irradiation is a priority.

NESTING SITES AND REPRODUCTIVE STATUS OF OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) AT ANDHRA COAST OF BAY OF BENGAL, INDIA

P.S. Raja Sekhar[1]

[1]*Dept. of Environmental Sciences, Andhra university, Visakhapatnam - 530 003, India*

Olive ridley sea turtle (*Lepidochelys olivacea*) is the most abundant in the Indian Ocean and nests along the coastal areas of India. The Andhra Coast in the Eastern Part of India runs parallel to Bay of Bengal between 12040' and 19.070N Latitudes and 770 and 84040' E Longitudes. This part of coast is a total length of 972 km passing two major perennial rivers the Godavari and Krishna with extensions of Eastern Ghats abutting the Bay of Bengal harbor ideal remote beaches of sandy and rocky coastline. This part of coastline harbor nesting habitats to Olive ridley sea turtle (*Lepidochelys olivacea*) for intensive sporadic nesting activity, while they are migrating from Indian Ocean to the Arribada mass nesting sites at Gahirmatha and Rusikulya river mouths of Orissa coast, India. For collection of data on sea turtle nesting the coastline of Andhra Pradesh was divided into four major Zones: (i) The southern art of coastal strip Zone-I is contains sand spits, ridges at Godavari and Krishna River mouths, whereas Zone-II areas with rocky beaches succeeded by primary and secondary sand dunes; Zone-III beaches of high elevated flat terraced sandy beaches; and Zone-IV of sandy ridges at small ephemeral rivers and backwater areas. Nesting surveys were conducted during winter months (From December, 2014 to April, 2016) to assess the status of nesting activity of Olive ridley based on Nesting Crawl Marks and Body Pits: Successful Nesting Crawls (SNC), False Nesting Crawls (FNC) and Reproductive Status: Freshly Laid Nests (FLN); Nests Opened by Predators (NOP) and Empty Nests with Hatched Egg Shells (HES). Olive ridley turtle nesting activity begins in early January and continues until the end of April, with a peak nesting during February and March. Highest frequency (80%) of nesting 30 to 40 for km-1 beach length was recorded at sand spits, and sand bars of Godavari and Krishna River mouths and Lowest Nesting Crawls 5-10 for km-1 was at main land beaches. The nesting density was highest ±40 nests/ lengthkm-1 at Godavari and Krishna River mouth sites in Zone-I, whereas the mainland beaches of Zone-II&IV were recorded ≤5-10 nests/ length km-1. Lowest nesting density was recorded ±3-5 nests/lengthkm-1 at Zone–III of rocky beaches of calcareous origin. The number of crawls for km in the river mouth was much higher than the mainland beaches. A total of 4,000 nests were laid an average 40 nests for km-1 from January to April during 2014 to 2016 years. The present study has identified two important new nesting sites of Olive ridley sea turtles at Godavari and Krishna River mouths of Zone-I, and between Vamsadhara, Bahuda rivers of Zone-IV. The congregation of breeding population during the nesting season was highest in the vicinity of these sites. Thus, these new sites of rookeries are recommended to develop into "Conservation Reserves" for Olive ridley sea turtle nesting and reproduction.

THE HYDRIC ENVIRONMENT INSIDE A TURTLE NEST: HOW DOES MOISTURE AFFECT DEVELOPMENT?*

Itzel Sifuentes-Romero[1], Boris M Tezak[1], Jeanette Wyneken[1], Sarah L. Milton[1]

[1]*Florida Atlantic Universtiy*

Turtle eggs are profoundly affected by environmental conditions during embryonic development. Experimental studies suggest that the interaction between the hydric environment and the thermal environment influence embryonic development, sex determination and consequently sex ratio. With regard to water content in the substrate, it has been shown that wetter substrates produce more males, whereas drier substrates produce more females. These results are consistent with findings from field studies where sex ratios obtained from loggerhead turtle (*Caretta caretta*) nesting beaches show a weak relationship with temperature recorded in situ. However, when the effect of moisture (particularly rainfall) is added to nest temperatures, sex ratio trends become more predictable. The freshwater turtle *Trachemys scripta*, is an emerging animal model species that, in recent years, has gained increasing attention for the study of several developmental processes. In this study, we used *T. scripta* as a surrogate for loggerheads to test the effect of moisture on (i) embryonic growth (ii) sex ratio, and (iii) sex determination through gene expression and methylation patterns of Sox9 and aromatase (two important sex determining genes). *T. scripta* eggs were incubated under different moisture regimes that paralleled conditions used previously in studies of loggerhead incubation temperature, moisture and sex ratios. Throughout the course of the experiment, two embryos were sacrificed each week to verify and document development up to stage 26 (last stage before hatching). Egg mass, embryo mass, and water content were recorded. Differentiated gonad samples were collected after the thermosensitive period (TSP) and one gonad from each embryo was preserved for DNA/RNA extraction and its counterpart was prepared for histological identification of sex. We found an effect of incubation moisture on the embryonic development reflected in growth rate, water content of the eggs and sex ratio. Gene expression analyses showed a dimorphic expression between male and female in aromatase (expressed only in females) and Sox9 (only expressed in males). Furthermore, we found a sex-specific methylation pattern in the aromatase promoter that is consistent with the expression patterns. To our knowledge, this is the first study to address the effect of moisture at genetic and epigenetic levels in systems presenting temperature-dependent sex determination (TSD). This study has been designed to analyze the effect of moisture on the development of turtles with TSD. Identifying the factors that influence development, sex determination, and hence sex ratio, will contribute to the development of more accurate demographic models. By using environmental factors to estimate the current and future reproductive potentials of sea turtle populations, we can ensure sea turtles continued survival.

INTRA-SEASONAL AND INTER-SEASONAL NEST SITE FIDELITY OF NORTHERN RECOVERY UNIT LOGGERHEAD TURTLES*

Brian M. Shamblin[1], Mark G. Dodd[2], S. Michelle Pate[3], DuBose B. Griffin[3], Matthew H. Godfrey[4], Michael S. Coyne[5], Ruth Boettcher[6], Campbell J. Nairn[1]

[1]*Warnell School of Forestry and Natural Resources,University of Georgia, Athens. GA, USA*
[2]*Georgia Department of Natural Resources. Brunswick, GA, USA*
[3]*South Carolina Department of Natural Resources. Charleston, SC, USA*
[4]*North Carolina Wildlife Resources Commission. Beaufort, NC, USA*
[5]*Seaturtle.org. Durham, NC, USA*
[6]*Virginia Department of Game and Inland Fisheries. Machipongo, VA, USA*

The scale of nest site fidelity has important implications for both population connectivity and the estimation of demographic parameters in marine turtle populations. Low nest site fidelity relative to the scale of tagging effort may lead to underestimation of clutch frequency, overestimation of remigration intervals, and biased annual survival estimates. Thus, identifying the appropriate scale for monitoring and management efforts requires a regional perspective. We performed genetic capture-recapture on the U loggerhead turtle Northern Recovery Unit through subpopulation-scale sampling of recorded clutches from the Georgia-Florida border through the northern extent of the species nesting range in Maryland. A singl egg was taken from each recorded loggerhead clutch and genotyped at 16 to 18 microsatellite loci to assign clutches to specific individual females. From 2010 to 2015, we detected 6,650 individuals that nested at least twice within a nesting season, providing 10,152 intra-seasonal nest site fidelity data points. The mean distance between successive clutches was 21.2 (20.1 – 22.2) km. The mean distance between the most distant clutches was 32.2 (30.8 – 33.6) km. Geographic variation in nest site fidelity was apparent across the study area and was temporally stable across the six years examined. Females nesting in the vicinity of the Cape Romain National Wildlife Refuge exhibited some of the highest nest site fidelity recorded, whereas females nesting in the immediately adjacent Grand Strand and proximal North Carolina coast had the lowest nest site fidelity. This pattern suggests that nesting beach selection cues and/or nesting habitat quality may influence nest site fidelity behavior. From 2011 through 2015, we detected 3,493 individual females during 3,912 remigrations. The mean displacement in median nesting latitude between years was 11.2 (10.2 – 12.2) latitude km (shifts in latitude translated to km). We detected 91 remigrations that involved shifts in median latitude of 100 km or greater. Females that were detected laying only one (n = 32) or two (n = 21) clutches in their first detection year accounted for more than half of these long-distance relocations, raising the possibility that these were neophyte females. Low nest site fidelity behavior may persist throughout the reproductive lives of a minority of nesting females. Alternatively, nest site fidelity may be shaped to some degree by previous nesting experience. Richardson *et al*. (1978) observed that females arriving untagged at the nesting beach laid fewer clutches and were less likely to be observed remigrating, prompting the hypothesis that neophyte females may have lower nest site fidelity than remigrant females. However, from the perspective of a single tagging beach, it is difficult to test this hypothesis because females arriving without tags or tag scars could be neophyte recruits or simply low site fidelity remigrants straying from other nesting beaches. Continued large-scale saturation sampling will permit robust assignment of females as neophytes or remigrants, and therefore the potential to explicitly test for differences in nest site fidelity behavior and reproductive output of the two groups.

MONITORING NESTING SEA TURTLES USING A THERMAL CAMERA

Rebecca Snyder[1], Abdulquadir L. Baruwa[1,2]

[1]*Seiche Limited Bradworthy Devon United Kingdom*
[2]*University of Bath Bath Somerset United Kingdom*

Every year female sea turtles come ashore to nest on tropical and subtropical beaches around the world. The nesting period is an important time for sea turtle researchers because it represents one of the only opportunities to obtain the counts used to estimate sea turtle populations, many of which are endangered or threatened. Existing monitoring methods include nightly patrols of nesting beaches; however, these patrols can be difficult to complete in remote locations and may require several individuals if nesting takes place along long stretches of beach. Additionally, beach patrols have the potential to unintentionally disturb turtles causing them to return to sea without nesting, producing a false crawl or abandoning the nest, and, in some cases, lead to the release of eggs while at sea rendering them unviable. An alternative to beach patrols may come in the form of enhanced monitoring technologies such as thermal cameras. Unlike low visibility cameras and night vision devices, which operate in the near infrared (NIR) portion of the spectrum, long wavelength infrared (LWIR, also known as thermal infrared) devices do not require light and can operate in complete darkness. Thermal cameras (cameras operating in the LWIR) produce images based upon temperature differences between objects. Therefore, thermal cameras positioned on nesting beaches detect sea turtles by sensing the small temperature differences in their body temperature compared to that of the surrounding environment, whether that be in air, in water, or on sand. Low light technologies have been used to monitor sea turtles and hatchlings; however little research has been conducted on the use of thermal cameras. To evaluate the efficacy of thermal camera technology to detect and monitor sea turtles, Seiche Limited conducted a field trial during the 2016 sea turtle nesting season in Florida. The field trial was conducted at the Barrier Island Sanctuary in Melbourne Beach, Florida. Approximately 51 hours of thermal camera data was collected over the study period. Sea turtles were recorded each day, with a total of 74 turtles observed. Turtles in the surf, emerging from the sea, excavating the nest (both body cavity and egg chamber), covering and camouflaging the nest, returning to the sea, and in the water were all captured on the thermal camera. Hatchlings dashing down the beach for the ocean were observed on one occasion and nest predators observed throughout the study period. The results of the proof-of-concept field study are promising and provide valuable insight on potential applications of thermal imaging for the monitoring of sea turtles.

VARIATION IN LOGGERHEAD AND GREEN SEA TURTLE SIZE AT MATURITY ON THE CENTRAL FLORIDA EAST COAST

Gustavo D. Stahelin[1], Katrina Phillips[1], Ryan M. Chabot[1], Katherine L. Mansfield[1]

[1]*University of Central Florida, Orlando, FL, USA*

Size at maturity is an important ecological measurement for many species, influencing reproductive output, offspring fitness, the number of seasons an individual can reproduce, and other demographic parameters. Different factors are considered to have an impact on size at maturity, including temperature, population density, geographical location, and growth rate. Analysis with captive-reared green turtles (*Chelonia mydas*) indicated that juvenile growth rate is the main predictor of their size at maturity (Bjorndal et al. 2013). Sea turtles may take up to 20-30 years to reach maturity, and several factors may influence their

growth; an example is poor nutrition, which may depress juvenile growth rates. A clear distinction between life stages is crucial for extinction risk assessments. Previous studies consider the smallest nesting female ever captured in a reproductive site as a reference for size at maturity for populations. Stewart et al. (2007) proposed that these small individuals should not be used as a guide, as few outliers could be driving conclusions about entire populations. Instead, the authors recommended using the lower threshold of the range within 95% of the sample (i.e., subtracting 2 standard deviations from the mean) as the reference for minimum adult size. We used this concept to reassess the size at maturity of loggerhead (*Caretta caretta*) and green turtles nesting at the Archie Carr National Wildlife Refuge (ACNWR), Florida, USA, and analyze variation over a 34-year timespan. The ACNWR hosts a regular reproductive aggregation of loggerheads (>11,000 nests per year on average), and a growing number of green turtles every year (>1800 on average). Changes detected within this large nesting aggregation are likely to be representative of other reproductive populations along the east coast of Florida. From 1982 to 2015, a total of 7,632 loggerheads (mean SCLnt 91.27 cm ± SD 5.92 cm) and 2,400 green turtles (99.99 ± 5.29 cm) were tagged and measured. A significant trend in the annual minimum size threshold was observed for both loggerhead and green turtles through time. A well-defined size at maturity interval will influence analysis of stranded animals, fisheries bycatch, and population and species' assessments, leading to more specific and effective conservation efforts for different life history stages.

HAWKSBILLS AT JUMBY BAY: INSIGHTS FROM 30 YEARS OF SATURATION TAGGING AT A NESTING POPULATION IN ANTIGUA, WEST INDIES*

Seth P. Stapleton[1], Kathryn Levasseur[2], Andrew S. Maurer[1,3], Alexandra L. Fireman[1], Jillian Tucker[1], Carol Guy[1], James Richardson[1,4]

[1]*Jumby Bay Hawksbill Project, Antigua, West Indies*
[2]*Dept. of Biological Sciences, University of South Carolina, Columbia, South Carolina, USA*
[3]*Dept. of Applied Ecology, North Carolina State University, Raleigh, North Carolina, USA*
[4]*University of Georgia, Athens, Georgia, USA*

Populations of the critically endangered hawksbill sea turtle (*Eretmochelys imbricata*) remain significantly depleted globally, although some sites (e.g., in the Caribbean) are exhibiting signs of long-term recovery and growth. Monitoring programs are important components of ongoing conservation programs, yielding valuable data on trends in abundance and enabling us to evaluate the impacts of these efforts. The Jumby Bay Hawksbill Project has intensively monitored the nesting population on Jumby Bay, a small barrier island located off the north coast of Antigua, for the past 30 years. The island is geographically isolated, and its privatization has meant that the island has been buffered against the threats facing hawksbills on mainland Antigua and elsewhere in the Caribbean. Research efforts have remained consistent over the previous 3 decades. The primary nesting beach (~650 m) is monitored nightly with hourly foot patrols from sunset to sunrise during the nesting season (June through November). These protocols allow field teams to identify virtually every hawksbill that successfully nests on the beach (i.e., saturation tagging). All nesting hawksbills are marked with flipper tags and a unique drill pattern in the supracaudal scutes to ensure that individuals are identifiable in subsequent seasons, and standard morphological metrics are collected. Over the course of the research program at Jumby Bay, more than 500 individuals have been marked. After a period of relative stability in the annual nesting cohort for the first 15 years of monitoring, the population exhibited strong growth during the subsequent 15 years. Mean annual cohort size has increased by more than 100% from the late 1980s to the 2010s. We summarize important reproductive parameters, including remigration intervals, number of clutches per nesting season, and clutch sizes, and evaluate potential changes in these metrics over the course of the monitoring program. This research has contributed valuable ecological information to hawksbill management and conservation efforts. Given the program’s longevity,

the relative isolation of Jumby Bay, and the intensiveness of monitoring, the Jumby Bay population also provides a benchmark for conservation efforts elsewhere in the region. Population growth after a long period of stability encourages patience in monitoring and conservation.

LONG-TERM MONITORING AND PROTECTION OF A RARE NESTING POPULATION OF HAWKSBILL SEA TURTLES (*ERETMOCHELYS IMBRICATA*) ON MAUI: TRENDS AND DEVELOPMENTS FROM 21 YEARS OF RESEARCH

Luke Sundquist[1], Suzanne Canja[1], Hannah Bernard[1], Bill Gilmartin[1]

[1]Hawai'i Wildlife Fund, Paia, HI

Despite conservation efforts for over 30 years and the gradual recovery of Hawaiian green sea turtles (*Chelonia mydas*), Hawaiian hawksbill sea turtles (*Eretmochelys imbricata*) remain on the brink of extirpation. Satellite and radio telemetry, beach monitoring, and in-water surveys show that this isolated hawksbill population forages, nests, and resides exclusively in the waters of the Hawaiian archipelago. The nesting population is concentrated on Hawai'i Island (~20 nesters/year), with a much smaller nesting population on Maui (0 – 4 nesters/year, mean = 1.6; 0 – 13 nests/year, mean = 4.4) and infrequent nests on other islands. Nesting was first documented on Maui in 1991, but not closely monitored until 1996, when Hawai'i Wildlife Fund partnered with federal, state, and local officials to establish a volunteer-based Hawksbill Recovery Project. The objectives of this project are to protect nesting females and hatchlings, identify and monitor biological trends and individual turtles, preserve critical beach and foraging habitats, and educate and involve the public in hawksbill conservation. Since monitoring began on Maui in 1996, nine nesting hawksbills have been observed, measured, and tagged. These females have laid 71 confirmed nests, with an additional 22 nests from at least four unobserved females. Six nesting females have remigrated to the same beaches over multiple seasons ranging between 3- and 17-year intervals, while a new female was tagged in 2014 and a new nesting beach was identified in 2015. Although only one female, "Orion" (H334), laid 5 nests in 2016, it was a record year for both hatching success (816/863 eggs=95%) and volunteer involvement for the program (150+ participants for over 3400 hours). Orion has now laid 24 total nests on the same two adjacent beaches since 2001, with a higher hatching success in each subsequent nesting year, from 63% in 2001, 70% in 2004, 75% in 2008, 80% in 2012, to 95% in 2016. This improvement may be influenced by female size and experience and volunteer nest protection, but is only possible because of the favorable beach conditions at this protected nesting site in a state park, including sand characteristics, distance from car traffic, nightly public beach closures, no commercial development, and limited artificial light. In contrast, some heavily developed, chemically polluted, and human-influenced beaches nearby have routinely had undeveloped and completely unsuccessful nests. Although numbers of females and nests on Maui continue to fluctuate at low levels each year, it is encouraging to see new nesting females, increased success from remigrants, and growing volunteer support within the program. Continuous monitoring of this resilient population has demonstrated the importance of nest and beach protection to enable mature females to nest successfully and to increase hatchling survival. With impending threats of sea level rise, increased beach development and human traffic, and predation from invasive species, inter-agency collaboration and community involvement is vital in order to preserve the next generation of hawksbills, not just on Maui but within any threatened population.

LEATHERBACK TURTLES IN SOUTH ASIA: A CASE STUDY FROM ANDAMAN AND NICOBAR ISLANDS, INDIA

Adhith Swaminathan[1], Naveen Namboothri[1,2], Kartik Shanker[1,3]

[1]Dakshin Foundation
[2]Ashoka Trust for Research in Ecology and the Environment (ATREE). Director
[3]Associate Professor at Indian Institute of Sciences. Founder Trustee

There is concern over the decline in the nesting populations of the leatherback turtle (*Dermochelys coriacea*) in some parts of the world, while other populations are stable or increasing. Sri Lanka and the Andaman and Nicobar Islands of India are currently the only sites in South Asia to host large nesting populations of leatherbacks in the northern Indian Ocean. Leatherback nesting in the Andaman and Nicobar Islands was first reported by Satish Bhaskar in 1979. Over the next two decades, surveys by Bhaskar and the Andaman and Nicobar Environment Team (ANET) provided some information on the distribution of nesting in the islands. A long term monitoring programme was established in Great Nicobar Island by ANET in 2000. The earthquake and tsunami of December 2004 severely affected these beaches as well as others in the Andaman and Nicobar Islands. The coastline and shore topography were altered in many of the islands and its impact on the nesting patterns of sea turtles of the region remained poorly understood. Since then, a long term monitoring camp has been established in Little Andaman Island, focusing on tagging, habitat monitoring, satellite telemetry and population genetics. The post-migratory routes of leatherback turtles from the Andaman Islands span the entire Indian Ocean. Rapid surveys conducted recently in the Nicobar Islands confirmed the recovery of previously known nesting beaches and nesting numbers comparable to earlier reports from Great and Little Nicobar Islands. The findings indicate a healthy and important population of leatherback turtles nesting in the region with ~200 nests in Little Andaman and ~1000 nests in the Nicobar Islands annually. The satellite telemetry program indicates two migratory corridors; one towards the western coast of Australia and the other leading to the eastern coast of Africa. The DNA analysis revealed 4 of the 11 reported global haplotypes namely, I, A, E and D found in the region.

PRIME REAL ESTATE: NEST PLACEMENT AND ITS EFFECT ON HATCHING SUCCESS IN LOGGERHEAD AND GREEN SEA TURTLES

MacKenzie Tackett[1], Katrina Phillips[1], Gustavo D. Stahelin[1], Katherine L. Mansfield[1]

[1]University of Central Florida, Orlando, FL, USA

Sea level rise has begun to impact beaches all over the world, and erosion from storm events is altering nesting areas for sea turtles. The opposite side of the beach is facing the threat of development that modifies dunes and vegetation, natural buffers to storms and erosion. With these pressures potentially reducing the size of the nesting beach, it is critical to understand how nest placement impacts incubating nests. The objective of this study was to test whether hatching success varies in relation to distance to the dune for loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) nests on the Archie Carr National Wildlife Refuge (ACNWR), in Melbourne Beach, Florida, USA. We determined hatching success based on the percentage of eggs that hatched in a given nest. Loggerhead and green turtle nesting on the ACNWR occurs in multiple locations relative to the dune. We grouped nests into three categories: before (1m seaward of the base of the dune), transition (within 1m in either direction from base of the dune), or on the dune (1m

landward of the base of the dune). We analyzed 591 loggerhead and 745 green turtle nests using mixed effects logistic regression models and nest data collected from 2010 to 2015 over a 21 kilometer stretch of beach. Most loggerhead nests were laid "before the dune", while green turtles nested most frequently in "transition" areas. We performed two hatching success analyses, one that included washed out nests and one that excluded these nests. While hatching success for loggerheads was lowest "on the dune", nests laid in the "transition" and "before the dune" did not differ from one another. Removing washed out nests did not affect the relationship between placement and loggerhead hatching success. In contrast, green turtle hatching success was lower "before the dune" than in the "transition" when all nests were considered. However, there was no difference among the three sections when washed out nests were excluded. Due to green turtles' tendency to nest later in the year during a more active period of the Atlantic hurricane season, sea level rise and storm frequency may have a stronger effect on these nests than loggerhead nests laid earlier in the year. Development could also make the available nesting area smaller for both species, putting more nests at risk. These results are valuable for understanding how a changing nesting beach could affect marine turtles in the future.

EVALUATING HATCHLING FITNESS IN RELATION TO NEST TEMPERATURES OF LEATHERBACK (*DERMOCHELYS CORIACEA*) SEA TURTLES AT JAMURSBA MEDI NESTNG BEACH, BIRD'S HEAD SEASCAPE – PAPUA BARAT, INDONESIA*

Ricardo F. Tapilatu[1], Amy N. Bonka[2], William G. Iwanggin[1], Hengki Wona[1], Yairus M. Swabra[1], Zadrak O. Woisiri[1], Riki M.P. Mayor[1], Erick Sembor[1], Petrus P. Batubara[1], Theofilus J.O. Ampnier[1], Gideon Y. Waroy[1], Roy Rumbiak[1], Thane Wibbels[2]

[1]Bird's Head Leatherback Conservation Program - Research Center for Pacific Marine Resources – University of Papua (UNIPA). Manokwari 98314 – Papua Barat INDONESIA
[2]Biology Dept – University of Alabama at Birmingham (UAB), AL – 35294 USA

Hatching fitness can significantly affect the survival of sea turtles, and has been shown to be influenced by nest temperatures during the incubation period. During the 2016 nesting season, we monitored fitness of hatchlings in terms of crawl and swimming speeds, and incubation temperatures from both in situ and relocated nests of the leatherback sea turtle (*Dermochelys coriacea*) at Jamursba Medi, Papua Barat, the primary nesting beach for this species in the Western Pacific. We used a drone as a video platform for monitoring hatchlings during their movements down the nesting beach and through the surf. Crawl speed was documented for an average of 10m prior to the hatchling entering the surf. Swimming speed was documented for 30 – 300m during their movements through the surf. During the current study, the hatchling leatherback sea turtles had a mean crawl speed of 0.04 ± 0.009 m/s and a mean swimming speed of 0.55 ± 0.13 m/s. We also monitored beach and nest temperatures throughout the incubation period. Hatchlings were collected from nests with daily mean beach temperatures of 30.3 ± 0.8°C (ranging from 28.6°C - 32.1°C) and nest incubation temperatures of 30.9 ± 1.3°C (ranging from 28.5°C - 33.8°C). The results of this study provide base-line data for evaluating hatchling fitness relative to crawl speed, swimming speed, and beach-nest incubation temperatures. For example, in the current study crawl speed was lower than those reported for leatherbacks in the eastern Pacific. Monitoring hatchling crawl speed and swim speed at the natural nesting beach provide useful metrics for evaluating hatchling fitness relative to factors such as nest incubation temperature and other ecological aspects of the nesting beaches.

BREAK ON THROUGH TO THE OTHER SIDE (OF THE EGG)*

Boris M Tezak[1], Itzel Sifuentes-Romero[1], Jeanette Wyneken[1]

[1]*Florida Atlantic University*

For turtles, the thermal environment that the embryo experiences during incubation plays a critical role in many biological processes, such as sex determination. As such, sex ratios of species with temperature-dependent sex determination are often estimated based on a variety of associated temperature values. The most common practices for estimating turtle hatchling sex ratios is through the use of proxies that are indirect: nest temperatures, beach temperatures, and incubation duration. However, the environment that determines sex is that of the inside of the egg. Here we ask the questions: (1) How does the temperature inside of a turtle egg relate to the temperature outside of the egg, in the clutch or the sand, and (2) How do thermal measurements change under different hydric conditions? Due to the protected status of sea turtles, eggs of a model species, the freshwater red-eared slider turtle (*Trachemys scripta*), were incubated at constant temperatures (29 °C or 31 °C) and were subjected to either wet or dry moisture treatments. We used thermocouples to measure air temperature and the temperature both inside and outside of the parchment-shelled eggs over 24 h trials. The temperatures were measured at developmental stages spanning the entire thermosensitive period. The majority of the embryos survived the trials. While the temperature inside and outside of the egg did not differ, moisture had a significant effect on incubation temperatures. The relationship between the outside environment and the inside of the egg is key to making accurate assumptions about conditions that the embryo experiences. Such information is relevant to understanding the process of temperature-dependent sex determination as well as embryonic growth.

ESTIMATING THE SEX OF SEA TURTLE HATCHLINGS VIA BLOOD SAMPLES

Boris M Tezak[1], Itzel Sifuentes-Romero[1], Sarah L. Milton[1], Jeanette Wyneken[1]

[1]*Florida Atlantic University*

In marine turtles, sex is determined based on the incubation environment that an embryo experiences, particularly temperature. The pattern of sea turtle temperature-dependent sex determination (TSD) is hot female, cool male. Because sex determination in turtles is so closely linked to environmental conditions, the most common prediction associated with climate change is that marine turtles will be at a higher risk of extinction if sex ratios become dramatically femalebiased. These concerns highlight the importance of identifying current and historical sex ratios at sea turtle nesting beaches. Estimating hatchling sex ratios at rookeries remains imprecise due to the lack of sexual dimorphism in young marine turtles and delayed sexual maturity. Most common practices for estimating sex ratios are indirect, based on nest temperatures, air and sea surface temperatures, incubation duration, and estimated thermosensitive period durations. However, there is insufficient evidence that these proxies indeed result in realistic primary sex ratios from natural sea turtle nests or rookeries. The lack of a simple, reliable, and nonlethal technique to verify the sex of hatchlings is at the foundation of this problem. The purpose of this study is to develop a technique to identify sex in marine turtle hatchlings via analysis of blood samples. Due to the protected status of sea turtles, we first developed our technique using blood and gonad samples of a model species, the red eared slider (*Trachemys scripta*), and after finding encouraging results, moved forward to test loggerhead (*Caretta caretta*) samples. We used Western blots to detect the expression of several proteins known to play an important role in sex differentiation in both *T. scripta* and *C. caretta* hatchling blood samples. The

presence of these proteins were then compared to the results from laparoscopic or histological procedures in order to validate this approach. Finding a sex-specific marker in hatchling turtle blood samples would allow for large scale measurements and verification of naturally occurring sea turtle sex ratios, a crucial step in assessing the impacts of climate change on turtle demographics.

WEATHERING OF HAWKSBILL TURTLE CRAWLS ON THE ISLAND OF BARBUDA: IMPORTANCE FOR ESTIMATING SIZE OF NESTING INDIVIDUALS AND UNDERSTANDING THE ROLE OF ABIOTIC FACTORS ON CRAWL APPEARANCE AND SIZE*

Nancy E. Todd[1], Maxine Montello[1], Melissa LaCroce[1], Wendy McFarlane[1]

[1]Department of Biology, Manhattanville College, Purchase, NY, USA

Estimating the size of sea turtles that are part of a nesting population is important for studying demographics. A few previous studies have suggested that the size of a turtle's crawl or track can be correlated to carapace size, and even clutch size. On the island of Barbuda, the nesting population is so large, and the beaches so extensive, that it is often difficult to observe turtles in the act of nesting, and actual measurements of turtles can be difficult to obtain. However, crawls that are a day to several days in age are abundant on the island's beaches. The focus of this pilot study was to monitor fresh crawls by turtles over a period of 1-7 days to observe the weathering of the track, disturbance by rainfall and wind, and to document the change in track width over time. Three tracks were monitored over a three-day period and two tracks over a four-day period from Coral Bay, on the southern coastline, which is characterized by wet and finely packed sand. No significant difference was noted until after day three, when the tracks became weathered enough to cause significant variation in measurements. For comparison, an up track (from water to nesting site) and a down track (to water from nesting site) from a dryer, more coarsely packed south-western beach subject to wind erosion (Palmetto Point) was measured on the first, 3rd , and 6th days. Day 3 was significantly different in measurement from day 6 on the up track, but not significantly different in the down track. Finally, an up and a down track from a finer-grain, deep and loosely packed eastern beach (Seaview) were measured over a 7-day period. Significant difference was found from day 1 to day 3, and also from day 5 to day 7 in the up track, but no significance was found in the down track measurements. Data collection on a few nesting turtles and their corresponding tracks has also been initiated. The track size of four nesting females was correlated with their carapace width, with an R2 of .86, indicating a very close correlation. However, due to the small sample size, more data collection is necessary. The results of this pilot study indicate that it is possible to: 1) Identify species from the crawls; 2) determine directionality of crawls (up to nesting site and down); and 3) accurately estimate turtle size from crawl width up to 3 days from the initial crawl. In addition, crawls may be more distorted when turtles are climbing up the slope of a beach (full of eggs), versus sliding down the slope following nesting (lighter in weight), and that grain size, compaction and moisture affect the stability of the track over time, particularly after day 3. In conclusion, this pilot study provides new information about track weathering and how it correlates to turtle size, which will be very important tools for examining Barbuda's nesting sea turtle demographics over time.

EFFECT OF SEA SURFACE TEMPERATURE ON THE DURATION OF THE INTERNESTING PERIOD OF GREEN TURTLES (*CHELONIA MYDAS*) IN NORTHWEST COSTA RICA

Veronica Valverde-Cantillo[1], Nathan J. Robinson[2,3], Pilar Santidrián-Tomillo[3]

[1]Escuela de Ciencias Biológicas, Facultad de Ciencias Exactas y Naturales, Universidad Nacional, Heredia, Costa Rica
[2]Indiana Purdue University Fort Wayne, Fort Wayne, Indiana, USA
[3]The Leatherback Trust, Goldring-Gund Marine Biology Station, Playa Grande, Costa Rica

Temperatures affect the physiology and behavior cycles of sea turtles. It has been suggested that the duration of the inter-nesting interval is tied to local temperatures in gravid. In this study, we analyzed the effect of local Sea Surface Temperature (SST) on the duration of the interesting period of green turtles (*Chelonia mydas*) that nested at Cabuyal, on North Pacific Costa Rica. Specifically, we calculated the duration of the inter-nesting interval for 160 nesting green turtles over five nesting seasons (2011-2016) and compared it to the average SSTs from the known interesting habitats for this population. We found a linear relationship between both variables, and the internesting interval decreased as the temperature increased. Additionally, we detected intra and inter-annually differences in the duration of internesting period. Mean (±SD) internesting period ranged between 12.3 ± 1.9 days in 2015-2016 and 16.1 ± 2.2 days in 2011-2012. The interesting periods became longer as SST decreased throughout the season. The effect of SST on the duration of the internesting period indicates that water temperature has a direct effect on sea turtles' reproductive cycle, probably due to an acceleration of their metabolism. Sea temperature raising because of global warming, may produce a shortening in the nesting seasons affecting the reproductive process in sea turtles.

LONG-TERM MONITORING OF MARINE TURTLE NESTING ACTIVITY REVEALS SPECIES-SPECIFIC CHANGES ON BIOKO ISLAND, EQUATORIAL GUINEA

Dana Venditti[1], Bryan Featherstone[1], Heidi Rader[1], Gail Hearn[1], Mary K. Gonder[1]

[1]Drexel University, Philadelphia, Pennsylvania, USA

Four species of marine turtles (leatherback, *Dermochelys coriacea*; green, *Chelonia mydas*; olive ridley, *Lepidochelys olivacea*; and hawksbill, *Eretmochelys imbricata*) are known to nest on the 19 km of beaches along the southern shores of Bioko Island contained within the Gran Caldera Scientific Reserve (GCSR). For the past 16 years (2000-2016) the Bioko Biodiversity Protection Program (BBPP), an academic partnership between the National University of Equatorial Guinea (UNGE) and Drexel University, has recorded nesting marine turtle activity on these beaches. Data recorded annually spans the entirety of the nesting season from October through March. Comparisons between the current (2010-present) and previous (2000-2010) decades show a declining population of leatherbacks across the southern beaches while nesting activity of greens suggests long-term stability of the population between these periods. Over the past 5 years in particular, evidence supports claims of a declining leatherback population with over 2,500 encounters in the 2012-2013 season dropping to approximately 600 in the 2015-2016 nesting season. Analysis of tagging efforts help to determine more specific estimates of total population size over the previous four nesting seasons for both leatherbacks and greens. Despite stronger law enforcement resulting from collaboration between BBPP and INDEFOR-AP (National Institute of Forestry Development and Protected Area Management), illegal take of adult nesting female turtles continues. Development within

the village of Ureca, the only village fully contained within the GCSR, and completion of a paved road extending directly to the nesting beaches has allowed unregulated access and growth. The BBPP continues to document the increase in these incidences, as well as facilitate the education of both visitors to the GCSR and local guides participating in the exceedingly successful ecotourism entrepreneurial program.

EFFECTS OF SAND PARTICLE SIZE ON HATCHING, EMERGENCE AND LOCOMOTOR PERFORMANCE OF LOGGERHEAD TURTLE HATCHLINGS

Maoko Wada[1], Ryohei Fujimoto[2], Shohei Kobayashi[1], Yoshinori Kumazawa[2], Tomomi Saito[3]

[1]Usa Marine Biological Institute
[2]Kochi University
[2]Tokyo University of Agriculture and Technology

The ecology of sandy beach environments has been severely impacted in recent decades as environmental degradation has increased. Furthermore, even in cases where coastal restoration measures have been implemented, recovery is typically slow. Consequently, sea turtle eggs in such environments often need to be relocated to hatcheries in order to avoid loss due to natural disasters and poaching. While numerous problems have been identified regarding artificial management of turtle eggs, the development of methods and techniques for rearing turtle eggs is considered an effective approach for conserving sea turtles. We recorded the landing and nesting locations of female loggerhead turtles (*Caretta caretta*) every morning from May to August in 2013 to 2015 at the Niyodo River mouth in Kochi Prefecture, Japan. Field survey results showed that the nesting success (number of nests /number of nesting attempts x 100) was affected by the sand particle size at the nest sites. When the sand was very fine, the nesting success and the number of nests increased. We also considered that there was a relationship between the characteristics of cracks at the sand surface above the nest and the time taken for hatchlings to emerge. Based on the assumption that the sand particle size affects the timing of nest-atrium collapse and hatchling fatigue, we examined the influence of sand particle size on hatching characteristics and hatchling locomotor performance. In 2014 and 2015, the eggs from nine nests were collected and separated into two experimental groups in a hatchery. One group of eggs was incubated in fine sand (D_{50}=0.5-0.6 mm) and the other was incubated in coarse sand ($D<_{50}$=1.1-1.4 mm). Both sand-grain diameter classes were present at the original nesting sites at the Niyodo River mouth showing nesting successes of greater than 50% in the study period. Compared to the nests comprising coarse sand, the hatching success rate and hatchling mortality rate were higher and lower in fine sand, respectively. The hatchlings from fine-grained sand nests tended to emerge in larger groups and to have higher locomotor performance. For example, the mean first group emergence rates (number of individuals that emerged in the first group / number of all hatchlings x 100) were 72.7% in fine sand and significantly higher than that of coarse sand nests, 44.1% ($p<0.05$). The crawling speed (mean ± SE) of hatchlings from fine sand (7.2 ± 0.3 cm s-1) was significantly faster than that from coarse sand nests (5.3 ± 0.4 cm s-1) ($P<0.001$). The mean swimming thrust (mean ± SE) of hatchlings from fine sand (32.8 ± 1.4 mN) was significantly larger than that from coarse sand nests (25.9 ± 1.4 mN) ($P<0.001$).Thus, use of fine-grained sand for incubation beds in artificial hatcheries will increase hatchling survival.

ASSESSING THE NEED AND IMPLICATIONS OF SEA TURTLE NEST RELOCATION*

Matthew Ware[1], Jacqueline Sablan[2], Alyssa Getz[2], Dianne Ingram[2], Mariana M. P. B. Fuentes[1]

[1]Florida State University
[2]US Fish & Wildlife Service

Sea turtles lay their eggs in sandy shores, which are at risk of groundwater inundation, wave wash-over, and erosion during their incubation. To mitigate these risks and improve sea turtle population recovery, nests laid near the high tide line are commonly relocated. When performed correctly, relocation can have minimal costs to nest productivity while providing an opportunity for outreach education. The 2008 Recovery Plan for the North Atlantic Population of Loggerhead Sea Turtles states that management actions "should be carefully evaluated to determine their potential risks and conservation benefits" and performed in the "least manipulative [way] possible". More detailed information is required to meet the Recovery Plan's objectives and better protect sea turtle nests from inundation. To better understand the implications of nest relocation, potential alterations to the incubating microclimate were investigated. Nest productivity, thermal profile, inundation history, and sand characteristics (grain size and moisture content) were compared between original and relocated nest sites, along with in situ and relocated nests, for loggerhead sea turtle nests in Fort Morgan, AL, including the Bon Secour National Wildlife Refuge. In 2016, 94 sea turtle nests were observed, 20 of which were relocated. Nests were approximately evenly distributed between the wildlife refuge and residential Fort Morgan, but significantly more relocation occurred off-refuge. Mean incubation temperature and sand characteristics did not significantly differ between original and relocated nest sites, though tidal inundation temporarily increased incubation temperature at affected sites. The likelihood of inundation did not differ between original and relocated nest sites, but of the site pairs that were inundated, original sites demonstrated a 3.4-fold increase in inundation frequency. Nest productivity, mean incubation temperature, inundation frequency, and sand characteristics did not differ significantly by location or relocation treatment. Nest productivity varied widely with inundation stress – some nests endured up to 3 days of episodic inundation and demonstrated a hatching success of 89%. The number of wash-over events per site underestimated the number of groundwater inundations by 2.5-fold, indicating that wave run-up and wash-over (and therefore, distance to the high tide line) does not fully describe the inundation risk of nests. This highlights the need to reconsider and amend the current high tide line-based relocation decision criteria to also include the influence of nest elevation and beach slope. This will increase the effectiveness of relocation by reducing unnecessary nest manipulation, in line with the 2008 Recovery Plan.

EFFECTS OF SHADING ON ENDANGERED OLIVE RIDLEY SEA TURTLE NESTS AT TWO IMPORTANT ARRIBADA BEACHES: POTENTIAL METHOD OF MITIGATING CLIMATE CHANGE EFFECTS?

Florence Wen[1], Yendy J. Argüello[2], Luis Fonseca-López[3], Roldán A. Valverde[1]

[1]Southeastern Louisiana University
[2]Ostional Olive Ridley Sea Turtle Project
[3]Biocenosis Marina

Sea turtle sex is determined by nest incubation temperature, where warmer temperatures produce a higher ratio of females. As global temperatures are predicted to increase 0.3–4.8°C in the next 100 years, the

breeding potential of sea turtles may be adversely affected as a change of just 1°C can have significant impacts on sex ratios. Temperatures at Ostional, Costa Rica have been shown to reach upper lethal incubation limits during the dry season months (December to April), where no hatchlings were produced when incubated at 35°C or higher. The few hatchlings produced during the dry season had incubation temperatures less than 35°C but greater than 32°C, suggesting that most, if not all, hatchlings produced were females. This study attempted to determine the effectiveness of shading as a strategy to amend potential undesired effects of climate-induced temperature changes in the future. We experimentally shaded nests using varying levels of mesh and monitored the nest temperatures throughout incubation at two important arribada, or mass nesting beaches, in Costa Rica: Playa Ostional and Playa Nancite. We found that as shading percentages increased, the mean nest incubation temperature decreased. However, the mean incubation temperature throughout the different shade levels at Ostional was 32°C and higher, which is above the mean pivotal temperature of 30.5°C. We did not find any significant differences in hatching success throughout the shading regimes at Playa Ostional. We did, however, experience hatching success rates between 70–90% in the hatcheries which is increased from the average natural hatching success rates of 0.8–10% at these two arribada beaches. The main implication of this study is to demonstrate that artificial shade in hatcheries may be an effective way to combat periods of high temperatures by lowering nest incubation temperatures. In spite of this, we should consider any alterations of natural nests as a last resort to mitigate the potential harmful effects of rising global temperatures.

THE IMPACTS OF EXTREME HIGH TIDE EVENTS ON SEA TURTLE NESTING ALONG THE GEORGIA BARRIER ISLANDS

Alicia Wilson[1]

[1]*Georgia Cooperative Fish and Wildlife Research Unit, Warnell School of Forestry & Natural Resources, University of Georgia, Athens, GA 30602*

Threats to coastal Georgia barrier islands from global climate change include increasing vulnerability to storm surge, flooding and high tide events. Loggerhead sea turtles (*Caretta caretta*) utilize the Georgia coast as habitat for reproduction. A study to quantify the changes in frequency of high tide events and assess the biological impact and subsequent nest success on sea turtles was initiated during the 2016 nesting season on four of Georgia's barrier islands. To evaluate nesting behavior, we measured nest elevation, microhabitat elevations and distance to previous night's high tide on 1,010 nests from Ossabaw Island (426), Sapelo Island (218), Little St. Simon's Island (223) and Jekyll Island (143). In initial analysis of data for some nesting beaches, nest success was positively correlated with elevation. Preliminary time series analysis from the Fort Pulaski (Savannah River) tide gauge shows an increasing trend in the frequency of extreme high tide events. Predicting tidal trends will enable us to better understand how sea turtles will adapt their nesting behavior with an increasing frequency of extreme high tides. We will continue to assess the relationship of high tide events, elevation and nest success with data from the 2017 nesting season.

DETECTION DOGS FOR SEA TURTLE NESTING BEACH MONITORING, MANAGEMENT, AND CONSERVATION OUTREACH*

Blair Witherington[1], Pepe Peruyero[2], J. Rachel Smith[1], Marty MacPhee[1], Rebekah Lindborg[1], Emily Neidhardt[1], Anne Savage[1]

[1]*Disney's Animals, Science and Environment*
[2]*Pepedogs*

Sea turtle research and conservation at nesting beaches involve nest counts, egg translocation, screening for predators, and marking to reduce human interference and facilitate measurement of egg survivorship. Accurate clutch location and confidence in clutch presence are priority objectives for these actions. Surveyors attempting to find eggs after the turtle has left the nest typically rely on visual signs, or on invasive methods such as probing the nest mound with a rod. In this paper, we describe results of a passive technique to find eggs using alert behaviors trained in detection dogs. Our study took place at Disney's Vero Beach Resort® during the 2015 and 2016 nesting seasons. The dog in this study was a 2–3-year-old "pocket" beagle named "Captain Ron" (CR). The target training scent was oviductal fluid (cloacal mucus). Initial training (6 weeks) at an inland facility included odor imprinting, then repeated trials during which CR was rewarded with a toy upon positive behaviors including a target-scent "alert" (nose/forepaw point and sit). In 2015, an initial test of CR's egg-detection was 100% accurate both in correct positives (n=4) and correct negatives (n=3). In 2016, surveyors recorded CR's alert responses at 69 loggerhead crawls and 12 green turtle crawls, and recorded horizontal distance between alert and egg locations in 37 nests. All incorrect determinations (n=3) occurred during initial weeks of the season, with total false positive and false negative rates of 1.2% and 2.4%, respectively. Rates during the months of July and August were each 0.0%. The distance between the alert location and top eggs approached zero following the first month of sampling. Mean distance during the last two months of the season was 3 cm. An ancillary benefit to having a detection dog as part of a conservation program may be the availability of the dog for outreach efforts. Both within and outside of the sea turtle nesting season, we incorporated CR into conservation outreach events that reached approximately a million people.

PREDOMINANTLY FUNGI SPECIES IN THE LOGGERHEAD SEA TURTLE, *CARETTA CARETTA*, NESTS AT DALYAN, TURKEY

Ahmet Yavuz Candan[1], Yusuf Katılmış[1], Çağrı Ergin[1]

[1]*Pamukkale University, Denizli, Turkiye*

The loggerhead sea turtle, *Caretta caretta*, is a threatened species being monitored by many conservation bodies. The IUCN Species Survival Commission (SSC) being one at the forefront. For Cheloniidae, there is very little empirically related knowledge on the relationship between colonized fungal species and embryonic-stage of turtles. A different type of fungi has been reportedly inferred from nest sand from beach, eg. Terengganu, Costa Rica, Oman. The aim of this study was to investigate predominantly fungal species on sea-turtle nests at Dalyan area, Turkey in the nesting season. Our 16 nest sands from 50 cm deep and above had been chosen for sampling. Samples were gathered on two separate occasions: detecting laying time or ending of incubation time. After sampling with sterile transport containers, all samples had been cultured with Sabouraud dextrose agar within 24 hours. Sterile saline was used for collecting supernatant fungal species. All agar plates were incubated at room temperature for 10 days. After presumptive fungal

identification with microscopy, ITS sequencing was meticulously applied to all fungal species. As a result, in total 2 fungi had been isolated from all the accumulated nests. Although 11 species had been cultivated, the majority of these fungal isolates were Aspergillus sp. (68%), Chaetomium sp. (27%) and Fusarium sp. (5%). Low percentile species were not recorded. In total, infections were detected in 66% of dead embryos in the samples. In conclusion; our results show that mycotoxigenic fungi may be an important indicator of yet undetected problems in the Dalyan sands. Replication of our methodology on other beaches within the local Dalyan beach would give a more accurate data set. Further studies are planned for a greater sample screening of mycotoxin-producing fungi to prove or disprove any apparent threat to the Cheloniidae eggs.

Population Biology and Monitoring

WHAT LONG-TERM TAGGING AND MONITORING OF A NESTING POPULATION TELL US? THE LAST 7 YEARS EVALUATION OF LOGGERHEAD POPULATION IN DALYAN, TURKEY

Musa Azmaz[1], Doğan Sözbilen[1], Eyup Başkale[1], Yusuf Katılmış[1], Yakup Kaska[1]

[1]Pamukkale University, Turkey

Dalyan Beach has the largest nesting loggerhead turtle population in the westernmost Mediterranean coast of Turkey. Monitoring and tagging studies have been carried out in the last 29 years. A significant increase has been observed in the annual number of nests in recent years. In 2000's average annual nest number was 253.4 (min: 197, max: 291), but in the last seven years from 2010 to 2016 the mean number of nests was 431.1 (min: 278, max: 658). We evaluated seven years of nesting and tagging data (from 2010 to 2016) to explain the change of the population structure of nesting loggerhead on Dalyan Beach. In these 7 years, a total of 3.018 nests were laid. We calculated a range of 3.6 to 4.2 clutches per female in the study period (average is 4) which claims that 755 individuals made 3.018 nests. During the study period, 595 individuals (78.8% of expected) were observed by tagging efforts but only 65 (10.9%) turtles recaptured. We also observed that an increasing number of individuals are nesting every year. The ratio of every year nesters (21 individuals) is low in total number of tagged turtles (3.5%) but has a big proportion in recaptured turtles (32.3%). This considerably low recapture rate can be explained by tag loss, new recruitments to population and deaths. Inter-annual nesting interval is known to be 2 to 3 years for loggerhead turtles which shows that the individuals of the nesting loggerhead population of Dalyan has nested at least twice in different breeding seasons during the study period. The remarkable increase in the annual nets numbers and low recapture rate shows that the Dalyan loggerhead population is receiving new recruitments. However, observing every-year nesters in the last six successive breeding seasons may point to a change in nesting pattern and inter-annual nesting interval of loggerhead turtles. This may also contribute to the increase in annual nest numbers. Nevertheless, the high tag-loss rate does not allow us to monitor every-year nesters' contribution to the annual nest numbers. Thus, using multiple tags on each individual and photo identification methods to achieve better results from long-term tagging studies should be considered immediately in the Mediterranean. Otherwise, the outcomes of the population monitoring studies and big tagging efforts would give misleading information about the Mediterranean loggerhead population in the future.

MODELING SUGGESTS A LONG-TERM, STABLE OSCILLATION UNDER STOCHASTIC CONDITIONS FOR THE LARGEST LOGGERHEAD NESTING ASSEMBLAGE IN THE NW ATLANTIC OCEAN*

Michael D. Arendt[1], Ryan R. Rykaczewski[1], David S. Wethey[1], Roger H. Sawyer[1], Joseph M. Quattro

[1]South Carolina Department of Natural Resources, University of South Carolina

Among well-managed sea turtle populations, recovery plans prescribe benchmarks for vital life history metrics which must be met and sustained before conservation success can be declared. In the Northwest Atlantic Ocean, a single distinct population segment (DPS) is recognized for loggerhead sea turtles

(*Caretta caretta*), but which is managed as five regional recovery units. Recovery units predominantly correspond to spatial distribution of annual nest counts, with the peninsular Florida recovery unit (PRU) comprising nearly three-quarters of annual DPS nesting. Several publications have analyzed a subset (i.e., the Index Nesting Beach Survey, INBS) of annual PRU nest count data since 1989, with emphasis on elucidating the cause of a precipitous decline between 2000 and 2007 as well as rapid resurgence in annual nest counts since 2008. Here we created a matrix model (MatLab) to predict annual nest counts during a 200-year run (and run 10k times) where annual nest counts were computed as the number of mature females divided by remigration interval and then multiplied by clutch frequency. The number of adult females annually was computed across age classes, and was calculated for each cohort as the annual nest count x clutch size x the proportion of eggs that hatched and entered the ocean x first year survival x the proportion of females at the end of the first-year x subsequent annual oceanic juvenile survival x age at neritic recruitment x annual neritic juvenile survival x age at maturity x annual adult survival. For the model population burn-in, the starting annual nest count (46,866) was nearly identical to the 24-year INBS mean nest count analyzed by Arendt et al. (2013). Stable model values for each parameter were largely based on DPS values in Table 1 of the 2009 Global Status Review for this species. Annual parameter values were selected from a probability distribution, with ±30% variability around stable values for most parameters, but only ±10% variability around survival due to a stable adult survival rate of 0.9. Linear-scaling of the North Atlantic Oscillation (NAO) in March of the year prior to nesting with remigration interval (negative = longer) and clutch frequency (negative = fewer) explained 27% (r = 0.52) of the annual variation in the 1989–2012 INBS nest count series. Ninety-five percent of predicated annual counts (n = 2M) were between 27,532 and 118,610 nests (mean = 58,807), with an absolute minimum of 7,973 nests. During sequential years, 95% of predicted annual counts fluctuated from -54,067 to +54,598 nests, but with as little as a 68-nest fluctuation. Model run slope was most closely correlated (r = 0.85) with mean model run nest count. Across model runs, mean nest count change ranged from -33% to 178% (median = 34%), but only 6% of model runs were associated with a reduction in mean nest count. These findings collectively suggest that fluctuation in annual INBS nest counts for loggerhead sea turtles since 1989 is well within the bounds of a longterm, stable oscillation generated under stochastic conditions.

EVALUATING THE EFFECTS OF PATERNITY ON BODY SIZE VARIATION IN LEATHERBACK SEA TURTLE HATCHLINGS (*DERMOCHELYS CORIACEA*) USING MICROSATTELLITES

Shreya Banerjee[1], Amy Frey[2], Carolyn M. Kurle[3], Kelly R. Stewart[2,4]

[1]*Scripps Institution of Oceanography*
[2]*Marine Mammal and Turtle Division, Southwest Fisheries Science Center, NMFS, NOAA, La Jolla, CA*
[3]*Biological Sciences Division, University of California, San Diego*
[4]*The Ocean Foundation*

Male leatherback turtles (*Dermochelys coriacea*) are rarely seen, and it is difficult to assess aspects of their reproductive success, such as quantity and body size of offspring. Molecular techniques can reveal paternal contributions to hatchlings without sampling males, provided that female identity is known. From June through August of 2012, 2015 and 2016, we measured body size and collected skin samples from leatherback hatchling clutches at Sandy Point National Wildlife Refuge, St. Croix, USVI. Using measurements from randomly selected 2016 nests, we found that the average weight of leatherback hatchlings at SPNWR was 45.6 g (SD = 8 g). The average within-nest standard deviation was 2.8 g, demonstrating that hatchlings are more similar in size to their siblings than to unrelated hatchlings. Four microsatellite markers were used to evaluate paternity within hatchlings from 18 leatherback nests laid by individual females in 2015; hatchlings were selected for large size variation. Maternal and hatchling

genotypes were used to reconstruct paternal genotypes and assign each hatchling to a father. Multiple paternity was found in six out of eighteen nests. For nests with multiple paternity, we compared the carapace lengths and weights of hatchlings from the same mother but from different fathers. We found that there was no significant difference between the sizes of hatchlings based on paternal identity within a clutch. Thus, there was no evidence for paternal genetic influence on body size within a clutch. In addition, four microsatellite markers will be used to evaluate multiple paternity in ten randomly selected nests laid by individual turtles in the 2016 season. We will determine whether nests with multiple paternity have greater body size variation than single paternity nests to evaluate the effect of multiple paternity on variation within a female's offspring. Very little is known about the reproductive behavior and strategies of male leatherbacks, so using molecular techniques to reveal these patterns can help managers assess the health of the population. Understanding factors that affect hatchling body size, which may be a measure of fitness, and identifying males through paternity analysis will help reveal aspects of male reproductive success and inform management strategies for leatherbacks.

REGIONAL GROWTH DYNAMICS OF GREEN TURTLES IN THE WEST ATLANTIC*

Karen A. Bjorndal[1], Alan B. Bolten[1], Milani Chaloupka[2], Vincent S. Saba[3], Cláudio Bellini[4], Maria A. G. dei Marcovaldi[5], Armando J. B. Santos[6], Luis Felipe Wurdig Bortolon[6], Michael J. Bresette[7], Jonathan C. Gorham[7], Stephen Connett[8], Barbara Crouchley[8], Mike Dawson[9], Deborah Hayes[9], Annabelle Brooks[10], Thomas Bethel[11], Lory Kenyon[12], Anne B. Meylan[13], Peter A. Meylan[14], Jennifer Gray[15], Robert Hardy[16], Beth Brost[16], Carlos E. Diez[17], Robert P. van Dam[18], Sue Willis[19], Mabel Nava[19], Kristen M. Hart[20], Michael S. Cherkiss[20], Andrew G. Crowder[21], Clayton Pollock[22], Zandy Hillis-Starr[22], Fernando Alberto Muñoz-Teneria[23], Roberto Herrera Pavon[24], Vanessa Labrada-Martagón[25], Armando Lorences[26], Ana Negrete-Philippe[27], Margaret M. Lamont[28], Allen M. Foley[29], Rhonda Bailey[16], Raymond R. Carthy[30], Russell Scarpino[31], Erin McMichael[31], Donna J. Shaver[32], Adriana Jardim[5], Milagros López-Mendilaharsu[5], Vicente Guzmán Hernández[33], Jane A. Provancha[34], Ralf H. Boulon, Jr.[35], Jaime A. Collazo[36], Thomas B. Stringell[37], Amdeep Sanghera[38], Peter B. Richardson[38], Annette C. Broderick[37], Quinton Phillips[39], Marta Calosso[40], John A. B. Claydon[39], Robert Wershoven[40], Tasha L. Metz[41], Amanda L. Gordon[42], Andre M. Landry, Jr.[41], Daniel González-Paredes[43], Andrés Estrades[43], Alejandro Fallabrino[43], Gustavo Martínez-Souza[43], Gabriela M. Vélez-Rubio[43], Brendan J. Godley[37], Andrew McGowan[37], Matthew J. Witt[44], Cathi L. Campbell[1], Cynthia J. Lagueux[1], Janice Blumenthal[45], Lucy Collyer[45]

[1]Archie Carr Center for Sea Turtle Research and Department of Biology, University of Florida, PO Box 118525, Gainesville, FL 32611, USA
[2]Ecological Modelling Services Pty Ltd, PO Box 6150, University of Queensland, St Lucia, QLD 4067, Australia
[3]NOAA National Marine Fisheries Service, Northeast Fisheries Science Center, Geophysical Fluid Dynamics Laboratory, Princeton University Forrestal Campus, Princeton, NJ 08540, USA
[4]Centro TAMAR-ICMBio, CLBI - Parnamirim, Rio Grande do Norte, 59160-530, Brazil
[5]Fundação Pró TAMAR, Rua Rubens Guelli, 134 sala 307, 41815–135 Salvador, Bahia, Brazil
[6]Fundação Pró-TAMAR, 53990-000 Fernando de Noronha, Pernambuco, Brazil
[7]Inwater Research Group, 4160 NE Hyline Dr., Jensen Beach, FL 34957, USA
[8]Family Island Research and Education, 2 Boughton Road, Newport, RI 02840, USA
[9]Geronimo Program, St. Georges School, PO Box 1910, Newport, RI 02840, USA
[10]Cape Eleuthera Institute, PO Box EL-26029, Rock Sound, Eleuthera, The Bahamas
[11]Hope Town, Abaco. The Bahamas
[12]Elbow Reef Lighthouse Society, Abaco, The Bahamas

[13]*Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Ave. SE., St. Petersburg, FL 33701, USA*
[14]*Natural Sciences Collegium, 4200 54th Ave. S., Eckerd College, St. Petersburg, FL 33711, USA*
[15]*Bermuda Turtle Project, 40 North Shore Road, Flatts FL 04, Bermuda*
[16]*Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, 100 8th Ave. SE., St. Petersburg, FL 33701, USA*
[17]*DRNA-PR, San Juan, Puerto Rico 00936*
[18]*Chelonia Inc, PO Box 9020708, San Juan, Puerto Rico 00902*
[19]*Sea Turtle Conservation Bonaire, PO Box 492, Kralendijk, Bonaire, Dutch Caribbean*
[20]*U.S. Geological Survey, Wetland and Aquatic Research Center, 3321 College Avenue, Davie, FL 33314, USA*
[21]*Cherokee Nation Technologies, NSU Center for Collaborative Research, 3321 College Avenue, Davie, FL 33314, USA*
[22]*National Park Service, 2100 Church St. #100, Christiansted, St. Croix, VI 00821*
[23]*Facultad de Agronomía y Veterinaria, Universidad Autónoma de San Luis Potosí, Apdo. Postal 32, CP. 78321, México*
[24]*El Colegio de la Frontera Sur -Unidad Chetumal, Av. Centenario Km. 5.5, Pacto Obrero Campesino CP 77014, Chetumal, Quintana Roo, México*
[25]*Facultad de Ciencias, Universidad Autónoma de San Luis Potosí, Av. Salvador Nava Martínez s/n, Zona Universitaria, San Luis Potosí, SLP CP 78290, México*
[26]*Dirección de Ecología Municipio de Solidaridad, Quintana Roo, México*
[27]*Parque Xcaret, Km. 282 Carr, Chetumal-Puerto Juarez S/N Col. Rancho Xcaret, Municipio de Solidaridad Playa del Carmen, Quintana Roo CP77710, México*
[28]*US Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL 32653, USA*
[29]*Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Jacksonville Field Laboratory, Jacksonville, FL 32218, USA*
[30]*US Geological Survey, Florida Cooperative Fish and Wildlife Research Unit, Gainesville, FL 32611, USA*
[31]*Florida Cooperative Fish & Wildlife Research Unit, Department of Wildlife Ecology & Conservation, University of Florida, Gainesville, FL 32611, USA*
[32]*Padre Island National Seashore, PO Box 181300, Corpus Christi, TX 78480, USA*
[33]*APFFLT-CONANP, Av. López Mateos Esq. Héroes del 21 de abril s/n, Col. Playa Norte, Cd. del Carmen, Campeche, CP 24129, México*
[34]*Environmental Services, Integrated Mission Support Services, Kennedy Space Center, FL 32899, USA*
[35]*National Park Service, Retired, 5000 Estate Enighed, PMB#68, St. John, VI 00830*
[36]*U.S. Geological Survey, North Carolina Cooperative Fish and Wildlife Research Unit, Department of Applied Ecology, North Carolina State University, Raleigh, NC 27695, USA*
[37]*Centre for Ecology and Conservation, University of Exeter, Penryn Campus, Penryn, Cornwall TR10 9FE, UK*
[38]*Marine Conservation Society, OverRoss House, Ross Park, Ross-on-Wye, Herefordshire HR9 7US, UK*
[39]*Department of Environment and Coastal Resources, National Environment Centre, Providenciales, Turks and Caicos Islands*
[40]*The School for Field Studies, Center for Marine Resource Studies, South Caicos, Turks and Caicos Islands*
[41]*Texas A&M University at Galveston, PO Box 1675, Galveston, TX 77553, USA*
[42]*Environmental Institute of Houston, University of Houston - Clear Lake, 2700 Bay Area Blvd., Box 540, Houston, TX 77058, USA*
Texas A&M University at Galveston, PO Box 1675, Galveston, TX 77553, USA
[43]*Karumbé, Av. Rivera 3245, Montevideo 11600, Uruguay*
[44]*Environment and Sustainability Institute, University of Exeter, Penryn Campus, Penryn, Cornwall TR10 9FE, UK*

[45]*Department of Environment, PO Box 10202, Grand Cayman KY1-1002, Cayman Islands*

Green turtles are long-lived, major consumers in marine habitats and move over large geographic areas. To evaluate spatio-temporal dynamics of green turtle growth, we compiled data on somatic growth rates (n = 6201) from 30 study sites throughout the West Atlantic (Bermuda to Uruguay) during a 43-year period (1973 through 2015). Green turtles in the study were all captured over foraging grounds and ranged in size from 23 to 119 cm straight carapace length. Generalized additive mixed models were used to evaluate six fixed effects (body size, mean year of growth increment, duration of growth increment, primary diet, carapace length type, and spatio-temporal interaction) and one random effect (project collecting the data, n = 30). The most striking result was the significant and steady decline in mean annualized growth rates that began in 1999 and continued to the end of our study. This decline is similar to those reported for loggerheads and hawksbills in the West Atlantic. The consistency of these temporal effects on growth rates among three sea turtle species – one primarily herbivorous and two primarily carnivorous – provides strong evidence that an ecological regime shift (ERS) in the Atlantic is driving growth dynamics. The ERS resulted from a synergy of the 1997/1998 El Niño Southern Oscillation (ENSO) – the strongest on record – combined with an unprecedented warming rate over the last two to three decades. Further support is provided by the strong correlations between annualized mean growth rates of green turtles and the Multivariate ENSO Index for all years and sea surface temperatures in the West Atlantic for years of declining growth rates. We discuss multiple stressors that could reinforce and prolong the effect of the ERS. Although density-dependent effects may play a role, the most likely driver appears to be indirect negative effects on foraging resources from warming waters. This study underscores the importance of extensive collaborations to answer critical questions on a regional basis for highly migratory sea turtles.

USING ISOSCAPES TO UNDERSTAND THE DYNAMICS OF FORAGING HOTSPOTS CONTRIBUTIONS TO LOGGERHEAD HATCHLING PRODUCTIVITY AT THE ARCHIE CARR NATIONAL WILDLIFE REFUGE, FLORIDA*

Simona Ceriani[1], John F Weishampel[2], Llewellyn M Ehrhart[2], Katherine L. Mansfield[2], Michael B Wunder[3]

[1]*Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Saint Petersburg FL, USA*
[2]*Department of Biology, University of Central Florida, Orlando FL, USA*
[3]*Department of Integrative Biology, University of Colorado Denver, Denver CO, USA*

Many organisms that move between geographically distinct feeding and reproductive areas are difficult to track with conventional methods. Marine turtle migratory connectivity has been increasingly studied using a combination of techniques such as satellite telemetry and stable isotope analysis. Satellite-tagged turtles have been used to validate the use of stable isotopes to infer foraging areas. Post-nesting females that migrate to different foraging areas can be distinguished by their overall isotopic signatures. Hence, sampling for stable isotopes on nesting beaches, where females or their nests are easily accessible, is becoming standard procedure at many study sites. Here, we focused on loggerheads nesting at the Archie Carr National Wildlife Refuge (Florida, USA), one of the largest nesting aggregations for the Northwest Atlantic loggerhead population. We updated previously developed loggerhead-specific isoscapes by including a larger number of known-origin adult females. We then applied a continuous-surface approach to determine the likely origin of 749 individual loggerhead females. We aggregated individual results to identify geographic foraging hotspots and examined the dynamics of inter-annual contribution of foraging areas to this rookery over a nine-year period (2007-2015). With the reproductive information of a subset of turtles (n=513), we estimated hatchling yields associated with females from the foraging hotspots. We

modeled the expected number of eggs and emergents to explore annual variation in egg production and egg survivorship, as measured by number of emergents (defined as number of hatchlings that emerged from the nest). Seven foraging hotspots were used consistently by loggerheads nesting at the Archie Carr National Wildlife Refuge. We found considerable inter-annual variability in relative importance of foraging areas to the nesting aggregation. However, the overall population-level summary for the nine-year study indicated the average relative importance of hotspots was similar. Foraging areas supporting large numbers of breeding females provided nutrients and energy for high egg production yielding viable offspring. Reproductive success differed among foraging hotspots. In particular, females assigned to southern foraging areas (the Bahamas and Florida Keys) laid nests that produced more offspring in all but one year of the study. We provide population-level information at a spatial scale finer than previously available that may help identify areas of conservation priority. Our approach can be used to guide conservation efforts to areas supporting higher numbers of foraging females and/or yielding higher hatchling production. This study represents the first implementation of probabilistic assignment of origin with isoscapes for untracked individual loggerheads in the marine environment. This method is applicable to other migratory species.

QUANTIFYING UNCERTAINTY IN LOGGERHEAD LENGTH-AT-AGE RELATIONSHIPS*

Brandon Chasco[1], Selina S. Heppell[1], Jim Thorson2

[1]Oregon State University
[2]NOAA

Loggerhead (*Caretta caretta*) sea turtles in the western Atlantic are listed as threatened under the United States Endangered Species Act. Assessing the status of this threatened population should be based on the management goals, while also maximizing the potential of the available data. Statistical age-structured models (ASM), such as those frequently used in commercial fisheries assessments, are a valuable tool for assessing the Loggerhead's status because they can integrate multiple sources data into a single modeling framework, and they partition different sources of mortality (e.g., natural verses fishing mortality) while tracking individual cohorts through time. Integral to ASM is the length-at-age relationship which links model estimates of cohort strength to the observed length frequency data from different surveys. Length-at-age relationships require paired observations of known length and age for individuals in the population. But unlike many teleost fishes, the Loggerhead length and age data is based on skeletochronology or mark-recapture studies where the true age is usually unknown. We seek to better understand the bias and uncertainty in the estimated parameters for length-at-age models when the true age is also estimated. Here, we simulate time-series Loggerhead growth data based on both stranding and tagging surveys, and then estimate the parameters for the growth process using mixed-effect models. In addition to quantifying parameter bias, we also examine the effects of observation and process error, model misspecification (e.g., choosing a logistic model when the true one is von Bertalanffy), and whether integrating data from both stranding and tagging surveys into a single modeling framework reduces parameter bias and uncertainty. We see this analysis as a valuable step toward assessing Loggerhead sea turtle population status and improving the management of the species through a more integrated cohort-based modeling approach.

CONNECTIVITY, POPULATION STRUCTURE, AND CONSERVATION OF ECUADORIAN GREEN SEA TURTLES

Jaime A. Chaves[1], Micaela Peña[2], Jhonnattan A. Valdés-Uribe[1], Juan Pablo Muñoz-Pérez[1,2,3], Felipe Vallejo[2], Maike Heidemeyer[4,5], Omar Torres-Carvajal[6]

[1]Universidad San Francisco de Quito
[2]Fundación Equilibrio Azul
[3]Galapagos Science Center
[4]Centro de Investigación en BiologÃ-a Celular y Molecular CIBCM-Universidad de Costa Rica
[5]Centro de Restauración de Especies Marinas Amenazadas CREMA
[6]Pontificia Universidad Católica del Ecuador

Studies of highly migratory species that increase our understanding of the dynamics of genetic diversity, migratory routes, and genetic connectivity are essential for informing conservation actions. Genetic data for green turtles (*Chelonia mydas*) from Ecuador have only been available from Galápagos Islands (GPS) rookeries, but not from foraging aggregations. Furthermore, green turtles from habitats associated with mainland Ecuador (Machalilla National Park; MNP) have not been sampled. To assess the genetic relationships between aggregations from these two regions and other regional populations, the mitochondrial DNA (mtDNA) control region was sequenced from 133 turtles. Conventional *F*ST (haplotype-frequency) and ΦST (sequence-based) values were low and nonsignificant between Ecuadorian rookeries, suggesting high connectivity between these sites located ca. 1,000 km apart. Mixed Stock Analyses (MSA) indicated a dominant (>94%) GPS-MNP contribution to both foraging grounds, with small and nearly negligible contributions from other rookeries in the region (e.g., Costa Rica and Mexico). While orphan haplotypes were not included in the MSA because their rookery of origin is not known, their close genetic relationships to Western and Central Pacific mtDNA clades suggests that a relatively large percentage of turtles at the combined foraging sites (>10%) have been involved in transoceanic migration events. The genetic links between GPS and MNP *C. mydas* nesting populations revealed by our study highlight the need to incorporate the nesting populations from coastal Ecuador in a more comprehensive future conservation planning.

CHARACTERIZING ATLANTIC HAWKSBILL SEA TURTLE (*ERETMOCHELYS IMBRICATA*) SIZE-AT-AGE RELATIONSHIPS AND SOMATIC GROWTH RATES USING SKELETOCHRONOLOGY

Jamie Clark[1], Larisa Avens[2], Lisa R. Goshe[2]

[1]University of South Carolina- Columbia
[2]NOAA- Beaufort | NC

Sea turtle size-at-age relationships and somatic growth patterns are difficult to characterize, due to relatively slow growth and high variability. However, it is crucial to study age to maturation and individual growth dynamics of hawksbill populations because of the need to conserve this endangered species. Skeletochronological analyses provide a detailed record of skeletal growth marks found in long bone cross-sections that are used to estimate age and growth rates in many sea turtle species. To obtain age and growth data for hawksbill sea turtles in the western North Atlantic, humerus bones and carapace length measurements were obtained from 87 wild hawksbill turtles found stranded and dead on beaches along the

Atlantic and Gulf of Mexico coasts of the US and skeletochronological analyses were performed. Juvenile hawksbills were found to have higher growth rates and variability among individuals than adult turtles. Growth rates for this sample population were comparable to those of similarly-sized sea turtles along the east coast of Florida, as well as those inhabiting the waters of Puerto Rico and the Virgin Islands. However, growth rates yielded by this study were lower than those of hawksbills in the British Virgin Islands and the Bahamas and higher than those in Barbados and the Cayman Islands. As several nesting populations contribute juveniles in different proportions to these foraging areas, it is possible that genetic differences may account for the different growth rates among populations within the Caribbean. Growth rates in the current study were also higher than those of Pacific hawksbill populations in Hawaii and Australia. The relationship between size and age was characterized using minimum and mean maturation size ranges from the literature to estimate age at maturation. While our small sample size of adults prohibited estimation of age for the mean size of nesting females, our results indicated that mean ages to maturation at minimum nesting sizes (i.e., 67.0 to 71.8 cm straight-line carapace length) range from 14 to 17 years of age for this population of hawksbill sea turtles. The results of this study provide the first size-at-age data for hawksbill sea turtles in the Atlantic and will be useful for improving species population models used to guide management decisions.

ISOTOPIC INSIGHT INTO THE PRE-NESTING FORAGING ECOLOGY OF FLORIDA'S NESTING LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*)

Christina M. Coppenrath[1], Jacob Lasala[1], John Baldwin[1]

[1]*Florida Atlantic University*

The migratory behavior of North Atlantic leatherback turtles (*Dermochelys coriacea*) has been documented in the wider Caribbean, but the migratory movements of leatherbacks nesting in South Florida are relatively understudied. Our knowledge of their migrations is currently limited to ten nesting females tracked from the east coast of Florida that either moved north to the Northern Atlantic or east to the coast of Western Africa. The results of this study bring to light the need for further investigation and larger sample sizes in order to identify and determine the relative importance of the different foraging areas for the leatherbacks nesting in South Florida. As Florida's nesting population has been experiencing increased nesting numbers (10-11% per year since 1979), it is important to know which geographic areas are providing the energy sources necessary for vitellogenesis, migration, and nesting. Here, we analyzed δ13C and δ15N signatures in whole blood and skin samples from leatherbacks nesting in South Florida between 2014 and 2017 to estimate where these nesters had been foraging prior to coming to South Florida to nest, most of which had likely been in the North Atlantic In 2017, we encountered remigrant turtles and were able to investigate how much their δ13C and δ15N signatures, and therefore their foraging patterns, had varied. The quality of forage has an impact on the quality of subsequent nesting seasons. It may be that North Atlantic leatherback turtles have a wide variety of foraging habitats available to them and are able to seek out food over a wide geographic region.

GLOBAL ANALYSIS OF SEA TURTLE LIFE HISTORY DATA FOR DEMOGRAPHIC STUDIES

Meghan B. Davis[1], Matthew D. Ramirez[1], Brandon Chasco[1], Susan E. Piacenza[1], Martha P. Rincon-Diaz[1], Selina S. Heppell[1]

[1]Oregon State University, Corvallis, OR, USA

Population assessments of threatened and endangered sea turtle species are often limited by inadequate and incomplete demographic information, which prevents accurate estimation of population size and trend, and ultimately designation of conservation status. Many reports and assessments have stressed the need to improve and increase data collection and vital rate estimation (both means and variance). In the case of sea turtles, data gaps are prevalent across all life stages, species, and regions, but a robust evaluation of where life history data gaps exist has yet to be conducted. In addition, there is a need for the creation of a central repository for the collection and storage of sea turtle vital rate data that is easily accessible to stock assessors, resource managers, and researchers. The primary objectives of this study are to (1) compile sea turtle vital rate data critical to population assessment from the literature, (2) identify data gaps by species and geographic region, and (3) develop region- and species-specific recommendations for the use of mean values and their variances for each demographic parameter. We are currently compiling a global vital rate database for all 7 species of sea turtle from over 600 journal articles, book chapters, governmental and technical reports, symposia proceedings, and theses. Source literature and data are being collected for the following demographic parameters: clutch size, clutch frequency, nest success (proportion of nests with at least one surviving hatchling), hatching success (proportion of eggs that hatch), emergence success (proportion of hatchlings that leave the nest), remigration interval or breeding probability, hatchling sex ratio, stage-specific survival rate, stage-specific somatic growth rate, size of (first time) nesting females, age and size at maturation, and life stage duration. We will then identify data gaps by life stage, region, and species for future research prioritization. Where data are available, we will also develop region- and species-specific recommendations for mean values and their variance that can be used in population models. Resulting metadata and bibliographical information will be made available online. We will illustrate our efforts with green sea turtle nesting data. This study provides a valuable evaluation of sea turtle vital rate data gaps that can be used to guide future research efforts, and will aid in parameterization of demographic models for population assessment.

RETROSPECTIVE REVIEW OF SEA TURTLE STRANDINGS IN MARYLAND FROM 1991-2014

Jennifer Dittmar[1], Anne Staudenmaier[2], Catherine Hadfield[1], Cindy Driscoll[3], Leigh Clayton[1]

[1]National Aquarium, Baltimore, MD 21202, USA
[2]University of Pennsylvania, School of Veterinary Medicine, Philadelphia, PA 19104, USA
[3]Maryland Department of Natural Resources, Cooperative Oxford Lab, Oxford, MD 21654, USA

The Chesapeake Bay and Atlantic coast of Maryland are important foraging grounds for juvenile sea turtles, with some studies suggesting site fidelity. Since 1990, the Maryland Department of Natural Resources (MDNR) and the National Aquarium (NA) have worked cooperatively to respond to sea turtle strandings within Maryland waters, including the Chesapeake Bay. MDNR responds primarily to dead sea turtle strandings, while NA responds to and rehabilitates live sea turtles. A 24-year descriptive retrospective

review (1991 - 2014) of sea turtle stranding data from Maryland was completed to evaluate species, age classes, and spatial and temporal stranding trends. The total number of sea turtle strandings was 607, with an average number of 30/year. The peak stranding month for most species was June. Loggerheads were the most commonly stranded species (487/607), followed by Leatherbacks (59/607). Loggerhead strandings were more likely to occur in the Chesapeake Bay than along the Atlantic Coast, and the primary age class for this species was subadults. The findings from this review have proved valuable in assessing sea turtle population demographics in Maryland. Further work to evaluate disease issues and potential causes of stranding are pending.

INCREASED PRESENCE OF JUVENILE KEMP'S RIDLEY AND GREEN SEA TURTLES IN SOUTH CAROLINA, USA: AN ANALYSIS OF TEMPORAL TRENDS AND SPATIAL DISTRIBUTION USING LONG-TERM DATASETS *

Elizabeth Duermit[1], Jennifer Cormany[1], Charlotte Hope[1], S. Michelle Pate[1]

[1]*South Carolina Department of Natural Resources*

In order to effectively manage federally listed sea turtle species, we must regularly assess their prevalence and habitat use. South Carolina (SC) waters provide important foraging grounds for juvenile Kemp's ridley (*Lepidochelys kempii*) and green turtles (*Chelonia mydas*). In recent years, strandings of juveniles of both species have increased throughout the state, whereas the loggerhead turtle (*Caretta caretta*)—the predominant sea turtle species in SC—strandings have decreased. Since the inception of the sea turtle stranding and salvage network (STSSN) in SC in 1980, Kemp's ridley strandings have increased steadily, from 2.0% (n = 44) of all strandings from 1980–1989 to 23.9% (n = 199) from 2010–2015; green turtle strandings, on the other hand, have increased exponentially, from 0.4% (n = 9) of all strandings from 1980–1989 to 11.6% (n = 97) from 2010–2015. Median stranding dates of Kemp's ridleys have become significantly earlier over the last three and half decades—from July 27 in the early 1980s to June 23 in 2010s. Rising water temperatures, particularly in earlier months, may allow individuals to utilize SC foraging grounds earlier, and for a greater portion of the year. Our analysis of 514 Kemp's ridley and 209 green turtle strandings from 1980–2015 is the longest dataset available for these species in SC, however we acknowledge the limits of using stranding data to make assessments of population status. Therefore, as a benchmark, we also examine records of 10 Kemp's ridleys (all caught since 2005) and 293 green turtles as bycatch in fishery-independent trammel net surveys at seven inshore locations in SC 1992–2015. These records also suggest increasing presence of juveniles of both species in recent years; 0.67% of trammel net sets caught green turtles from 1992–1996, compared to 2.0% from 2011–2015. Spatial analyses of trammel net and stranding data indicate increasing prevalence of Kemp's ridley and green sea turtles in inshore waters, and at greater distances inshore, today than at the inception of the STSSN in SC. The growing number of observations of these species may be an indication of success from decades of conservation efforts—a conclusion supported by increasing nesting numbers in Florida and the Gulf of Mexico. However, increasing occurrence in inshore and nearshore waters, which has coincided with a doubling in the coastal human population in SC, increases risks of negative human interaction such as boat strikes, incidental entanglement, and dredging operations. Implications of these newly defined patterns of spatial and temporal distribution of Kemp's ridley and green turtles should be considered in management action plans on the state and regional levels.

HOTSPOTTER: LESS MANIPULATING, MORE LEARNING, AND BETTER VISION FOR TURTLE PHOTO IDENTIFICATION

Stephen G. Dunbar[1,2,3], Dustin S. Baumbach[1,2], Marsha K. Wright[1,2], Christian T. Hayes[4], Jason Holmberg[5], Jonathan P. Crall[6], Charles V. Stewart[6]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc.), Loma Linda, CA
[2]Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA
[3]Protective Turtle Ecology Center for Training, Outreach, and Research - Honduras (ProTECTOR - Honduras), Tegucigalpa, Honduras
[4]Department of Science and Mathematics, Judson University, Elgin, IL
[5]Wild Me, Portland, OR
[6]Department of Computer Sciences, Rensselaer Polytechnic Institute, Troy, NY

The value of individual animals in research increases with the ability to identify each one from other individuals in the population. Individuals are often identified through markings, yet these may impact animal behavior and physiology. Photo ID (PID) has successfully been used to evaluate population dynamics, growth rates, behaviors, and movement in many animal studies, yet only recently emerged in sea turtle research with several studies still reliant on manual photo matching. Turtle studies using computer-assisted programs to match photographs have reported four common challenges that reduce efficiency and viability. These are: 1) the requirement to acquire clear, high-quality images at restricted angles, 2) time-consuming pre-processing of photographs before submission to the database, 3) the potential for high numbers of false matches in program outputs, and 4) the requirement for manual verification of many potential matches provided by the program. The computer vision program HotSpotter (HS), developed for PID of the Kenyan population of Grévy's zebra (*Equus grevyi*), works by localizing and matching SIFT keypoints using the Local Naive Bayes Nearest Neighbor search algorithm. We used HS to build a database of hawksbill photographs taken in-water during 2014 and 2015. We trained the program by submitting multiple photos of the head and both faces, and queried the program for matches. Initially, whether matches were found or not found, we labelled all photos from a single individual with that turtle's ID number until all photos from 2014 and 2015 were identified and the program trained for all individuals from those years. In 2016, we photographed, captured, and tagged turtles. Tags provided a positive measure of some individuals. Some turtles were photographed, but not captured for tagging. We then tested the database by submitting several head and face photos from each individual photographed in 2016, without providing tag numbers (if available). From each test a turtle ID number was returned and checked against the tagging record. For each query we visually inspected the top two results. If either of these was correct the query was marked as returning a correct match. We analyzed 4 classes of results (true tag match, true untagged match, true negatives, and false positives). We developed a database of 251 images from 2014 and 2015 used to initially train HS. From June – October 2016, we introduced an additional 639 images to the database. From these, we used a small subset to test HS matching. Out of 58 tests, HS correctly predicted and matched 90% of queries, and incorrectly predicted only 10% of queries. Advantages of HS are that the time required to manipulate photos is greatly reduced from other programs, since it requires only inserting two points on each photo to generate a "chip" (the examination field), photos of low quality can be used, and photos taken from many different angles are of benefit in training the program to recognize individuals. Future developments will automatically orient the photo and generate the chip, allowing input of photos and matching processes to integrate without the need for user manipulation.

INFLUENCE OF OCEANOGRAPHIC PARAMETERS IN SEA TURTLES STRANDINGS IN CANARY ISLANDS

Andrea Fariñas Bermejo[1], Ana Liria-Loza[1], Luis Francisco García Weil[2]

[1]ADSBiodiversidad
[2]University of Las Palmas de Gran Canaria

Throughout the year, more than 200 loggerhead turtle (*Caretta caretta*) strandings takes place on Canary Islands. This species is endangered worldwide, therefore, is very important to assess thoroughly the factors that could affect to his state, to achieve effective plans to control his loss. The information obtained to date, show the great human influence on the damage caused, however this data should be compared with the effects that would have the nature by itself. This study has carried out in order to understand the influence of some oceanographic parameters: temperature, chlorophyll concentration and Eddy Kinetic Energy (EKE) of the sea surface, on loggerhead stranding in Canary Islands. In this way, we are closer to identify where, how and when sea turtles are being affected. The results reflect the influence of these parameters on the stranding frequency, whose degree varies depending on the area and season. The information obtained has been satisfactorily useful to understand certain aspects of their behaviour related with specific oceanographic parameters.

THE APPLE DOESN'T FALL FAR FROM THE TREE: mtDNA GENETIC CHARACTERIZATION OF HAWKSBILL FORAGING GROUNDS IN THE EASTERN PACIFIC OCEAN*

Alexander Gaos[1,2,3], Rebecca L. Lewison[4,5], Michael J. Liles[1,6], Ana Henríquez[2,7], Sofía Chavarría[2,7], Ingrid L. Yañez[2,7], Kelly R. Stewart[3,8], Amy Frey[3], Peter H. Dutton[3]

[1]San Diego State University
[2]Eastern Pacific Hawksbill Initiative
[3]UC Davis
[4]Southwest Fisheries Science Center
[5]Pacific Islands Fisheries Science Center
[6]University of Texas at El Paso
[7]ProCosta
[8]The Ocean Foundation

Genetic analyses of nuclear DNA (e.g., microsatellites) are a primary tool for investigating mating systems in reptiles, particularly marine turtles. Studies over the past two decades have demonstrated that polyandry (i.e., females mating with multiple males) is common in marine turtles. In this study we investigated the mating structure of hawksbill turtles (*Eretmochelys imbricata*), a critically endangered marine turtle that is particularly threatened in the eastern Pacific Ocean, at Bahía de Jiquilisco in El Salvador, one of the largest rookeries in this ocean region. We collected samples from 34 nesting females and hatchlings from 41 clutches during the 2015 nesting season, including one nest from each of 27 females and two nests from seven additional females. Using six microsatellite loci, we reconstructed the paternal genotypes for 22–30 male turtles and discovered that 26.6–31.8% of males sired nests from multiple females, which suggests that polygyny (i.e., males mating with multiple females) may be a common mating structure for this

population. We also detected multiple paternity in four (11.8%) of the 34 females analyzed, confirming polyandrous mating strategies are also employed. Our findings represent the highest polygyny values reported to date for marine turtles and suggest there may be a limited number of sexually mature males at Bahía de Jiquilisco, likely the result of the small overall hawksbill population in this ocean region. Our results can support hawksbill management in the region and represent valuable baseline data for future studies at this and other hawksbill nesting grounds.

FIRST SEX RATIO OF A FORAGING AGGREGATION OF OLIVE RIDLEY SEA TURTLES IN THE EASTERN TROPICAL PACIFIC: ESTABLISHING BASELINES FOR CLIMATE CHANGE RESEARCH

Sydney J. Gaylor[1], Lindsey E. Peavey[2], Jeffrey A. Seminoff[3], Camryn D. Allen[4]

[1]UCSD
[2]UCSB
[3]Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California 92037, United States of America
[4]Ocean Associates, Inc. under contract to the Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California 92037, United States of America

Sex ratio data are a critical and often underused tool to assess the demography and reproductive potential of endangered species such as sea turtles, of which all seven species are listed as endangered or threatened. Sea turtle sex is determined by incubation temperature (not sex chromosomes) and until maturity, sea turtles lack sex-specific external morphology. Previous research has implemented radioimmunoassays to determine circulating testosterone (T) levels in mature and immature sea turtles and ultimately used the T data to determine the sex of a sea turtle. However, a non-hazardous technology, enzyme linked immunosorbent assay (ELISA), has become a preferred method to characterize T levels due to the low set up cost and lack of exposure to radiation. This study provides the first ELISA hormone assay validation for olive ridley (*Lepidochelys olivacea*) sea turtle blood plasma and characterizes the sex ratio of foraging aggregation of olive ridleys in the eastern tropical Pacific (ETP). Overall, the results indicated a male bias (1.9 M: 1.0 F) among adult and immature turtles sampled in 2006 during NOAA Fisheries' Southwest Fisheries Science Center Stella Abundance Research cruise in the ETP. While the results deviate from the standard 1:1 sex ratio, the data reflect a sex ratio for a single sampling year and provide baseline information to examine potential feminization of sea turtle populations due to climate change. In addition, the ELISA has been validated for olive ridley sex determination providing an alternative, non-hazardous and user-friendly technique for future olive ridley endocrinology research. Overall, this is the first sex ratio produced for a foraging aggregation of olive ridleys in the ETP and will be useful for population viability and sex-based survivorship analyses that can be used to shape further conservation measures.

STATISTICAL CHALLENGE: RECONSTRUCT TIME SERIES OF NESTING IN GUADELOUPE ARCHIPELAGO FOR 160 BEACHES FOR 3 SPECIES DURING 15 YEARS!

Marc Girondot[1,2], Antoine Chabrolle[3], Eric Delcroix[3], Alexandre Girard[1,2]

[1]*University Paris Sud, CNRS, AgroParistech*
[2]*University Paris Saclay, France*
[3]*Office National de la Chasse et de la Faune Sauvage, Guadeloupe*

Mathematical or statistical models are often built for ideal world. Another way to say the same is that often the model supposed that many hypotheses are respected. Several models have been proposed to analyze timeseries of nesting data and generally they are tested with data that respect the hypotheses: good coverage of nesting season and few beaches with high number of nests during the season for example. However, in real life, we have generally data that do not met these requirements: many small beaches poorly covered during the season with low number of nests on each. This is exactly the situation in Guadeloupe Archipelago: 3 species of turtles are nesting on 160 beaches and the number of nests per beach is very low. Using a collection of statistical tools, some of them being new, we have been able to analyze these data and draw a complete view of the nesting for the last 15 years. The statiscal tools are: Mathematical modeling of nesting season; Statistical modeling of sum of nest numbers; Statistical aggregation of several years in a single model of beach use. This methodology can be applied at any time- and spatial scale. Sources of the data: Acteurs du Réseau tortue marines de Guadeloupe*(RTMG) - Financements FEDER/Etat/Conseil régional Guadeloupe. *Associations AEVA, Le Gaiac, Evasion Tropicale, Kap Natirel, Ecolambda, Titè, réserves naturelles de Saint Martin, Agence territoriale de l'Environnement, Parc De la Guadeloupe, ONCFS, ONF, bénévoles du RTMG.

POPULATION DYNAMICS OF SEA TURTLES IN THE BIG BEND REGION OF FLORIDA*

Jeffrey Guertin[1], Michael J. Bresette[1], Jonathan C. Gorham[1], Cody Mott[1], Ryan Welsh[1], Steve Weege[1]
[1]*Inwater Research Group*

The shallow seagrass habitat of the Big Bend region of Florida serves as important developmental habitat for green (*Chelonia mydas*), Kemp's ridley (*Lepidochelys kempii*), and loggerhead (*Caretta caretta*) sea turtles. The Big Bend region has been identified as a location with historically high capture rates and extensive sea turtle habitat, but also as an area that lacked active sea turtle monitoring projects. The waters around Crystal River specifically were once the home of an active turtle fishery but the area has been relatively overlooked from a research standpoint. In 2012, Inwater Research Group (IRG) began a long term in-water study of sea turtle abundance and distribution in the Big Bend area in the waters near Crystal River. Quantitative data on sea turtle abundance was gathered using the HUNT (Haphazard Unmarked Nonlinear Transect) method and sea turtle captures were conducted via the rodeo and dip net methods. Visual surveys of the area have estimated sea turtle densities of more than 100 turtles per square kilometer in some locations, and to date the project has captured 244 loggerhead, green, and Kemp's ridley sea turtles across various size classes. Data will be analyzed to examine trends in species composition, abundance, size class distribution, recapture rates, morphometric trends, tag recovery information, and fibropapilloma rates. This long-term monitoring project will continue to provide insight into the population structure of turtles utilizing the near-shore waters of the Big Bend region of Florida.

BREACHING THE EASTERN PACIFIC BARRIER: INSIGHTS PROVIDED BY REGIONAL ABUNDANCE PATTERNS OF THE "YELLOW" GREEN TURTLES IN EASTERN PACIFIC FORAGING GROUNDS

Maike Heidemeyer[1,2], Juan Pablo Muñoz[3], Daniela Alarcón-Ruales[3], Cristina Miranda[4], Jaime A. Chaves[3], Daniel Sánchez[5], Susana Caballero[5], Didiher Chacón[6], Diego Amorocho[7], María Chavarría[8], Catherine E. Hart[9], Randall Arauz[2], Federico J. Albertazzi[1], Nathan F. Putman[10], Michael P. Jensen1[1], F. Alberto Abreu-Grobois[12]

[1]*CIBCM - Universidad de Costa Rica;*
[2]*CREMA*
[3]*Universidad San Francisco de Quito | Galapagos Science Center*
[4]*Equilibrio Azul*
[5]*Universidad de los Andes*
[6]*Latin American Sea Turtles*
[7]*WWF*
[8]*Universidad del Valle de Guatemala*
[9]*Red Tortuguera de México*
[10]*NOAA Atlantic Oceanographic & Meteorological Laboratory*
[11]*NOAA Southwest Fisheries Science Center*
[12]*Universidad Nacional Autonoma de México*

The circumglobally distributed green turtle (*Chelonia mydas*) encompasses a number of regional color morphs, but none are more iconic than the "black" and the "yellow" turtles associated with specific regions within the Pacific Ocean basin. Black turtles belong to eastern Pacific nesting stocks, extending from Mexico to Chile, and are the smallest, darkest and less colorful variants, having a diagnostically heart-shaped and posteriorly tapered carapace. In contrast, the yellow morphs are of western Pacific origin and are larger, being characterized by bright yellow, orange-to brown colored, oval shaped carapaces. These morphological differences have caused extensive debates on the taxonomic placement of these morphs, and on whether or not these are two sympatric, co-existing species in the Eastern Pacific. With the increasing genetic information available from stock characterizations and mixed stock analysis of feeding grounds, it has become clear that both eastern and western Pacific populations cross the Eastern Pacific Barrier to settle into probably temporarily developmental grounds thousands of kilometers away from their natal beaches. The drivers and the frequency at which these trans-oceanic displacements occur, however, remain unclear but they need to be understood in order to implement effective Pacific-wide conservation strategies. Results from regional in-water surveys spanning from Mexico to Galapagos (Gorgona Island (n=89), Machalilla National Park and the Galápagos Archipelago (n>500), Cocos Island (n=72), the Costa Rican coast (n=116), Guatemala (n=34), México (n>500) now offer an opportunity to analyze the variable patterns in the abundance of the yellow morphs at East Pacific foraging grounds and the phenomena associated with the recruitment. Our surveys here show that yellow turtles are found widely, albeit never dominant, at foraging grounds distributed as far East as the eastern Pacific islands, and along continental sites as far North as the northern coast of Costa Rica. Depending on the foraging ground, the yellow morph is found in frequencies from 1 to 50%. Phylogenetic analysis of mitochondrial control region sequences suggests origins in western Pacific stocks of American Samoa, French Polynesia and the Marshall Islands. However, the majority exhibited haplotypes with no reported origin, highlighting the need to extend genetic surveys into un-characterized nesting aggregations of Western Pacific habitats. By combining our results with size distributions and ocean dispersal modelling, we reconstruct an alternative developmental migration route for western Pacific turtles into the Eastern Pacific that provides insight into temporal and spatial variations of their transoceanic sojourn.

A PRIMER OF GREEN TURTLE STOCK DISTRIBUTION IN THE EASTERN PACIFIC: INSIGHTS FROM REGIONAL FORAGING GROUNDS*

Maike Heidemeyer[1,2], F. Alberto Abreu-Grobois[3], Michael P. Jensen[4], Randall Arauz[2], Didiher Chacón[5], Luis Fonseca-López[6], Diego Amorocho[7], Daniel Sánchez[8], Susana Caballero[8], Maria Chavarrí-a[9], Micaela Peña[10], Jaime A. Chaves[11], Juan Pablo Muñoz[11,12], Daniela Alarcón-Ruales[11,12], Todd Steiner[13], Federico J. Albertazzi[1]

[1]*CIBCM - Universidad de Costa Rica*
[2]*CREMA*
[3]*Universidad Nacional Autonoma de México*
[4]*NOAA Southwest Fisheries Science Center*
[5]*Latin American Sea Turtles*
[6]*Biocenosis Marina*
[7]*WWF*
[8]*Universidad de los Andes*
[9]*Universidad del Valle de Guatemala*
[10]*Equilibrio Azul*
[11]*Universidad San Francisco de Quito*
[12]*Galapagos Science Center*
[13]*Turtle Island Restoration Network*

The Eastern Pacific is known to host important green turtle (*Chelonia mydas*) populations distributed along the Latin American coast from México to Ecuador. With the increasing number of in-water surveys being conducted in the region, more and more foraging grounds have been identified, revealing a variety of habitats that are occupied during juvenile and non-reproductive life stages. Molecular markers, such as the mitochondrial DNA (mtDNA) control region (CR) have provided important insights into the geographical constraint of green turtle nesting aggregations in the Eastern Pacific, but still little is known on the regional distribution of these stocks throughout the species' life cycle. Because green turtles are highly migratory animals, defining the connectivity between foraging grounds and their reproductive stocks is of primary importance in designing effective conservations measures. With the aim to determine green turtle stock contributions to Eastern Pacific foraging grounds, we conducted mixed stock analysis (MSA) on seven foraging grounds located in the Galápagos Archipelago and Machalilla National Park in Ecuador (n=104), Gorgona Island in Colombia (n=82), Cocos Island (n=72), Dulce Gulf (n=71) and the North Pacific coast of Costa Rica (n=24) and Poza del Nance, Guatemala (n=34), using 770 base pair sequences of the mtDNA CR. A total of 36 haplotypes where identified, of which 90% where assignable to previously characterized nesting rookeries. Meanwhile the Galapagos rookery highly contributes to South- and Central American foraging grounds, the Costa Rican rookery is only dominant in geographically closer sites. Our MSAs suggest that the stock composition at these foraging grounds is driven by a variety of motors, including currents, nesting stock sizes and geographical distance, but are also dependent on the size-and age structures comprised. By combining our genetic results with morphometric data of the individuals sampled at foraging grounds, we reconstruct their possible dispersal and reproductive movements throughout the Eastern Pacific. Furthermore, the high encounter of "orphan" haplotypes (10%) highlights the need for further sampling of yet uncharacterized nesting aggregations in the Eastern Pacific.

GREAT, WE SAVED THEM! NOW WHAT?*

Selina S. Heppell[1]

[1]*Oregon State University*

With the possible exception of the enigmatic flatback turtle, all species of sea turtles are now much better shape than they were a few decades ago, and no species is in imminent danger of extinction. This does not mean that sea turtles worldwide are "saved" – many nesting beaches continue to show declines, some ocean basin-wide populations are still in danger of extinction, and large-scale impacts at sea and on major nesting beaches continue to threaten local populations. Nevertheless, as a whole, sea turtle conservation is a tremendous success story, and we have raised public awareness worldwide to appreciate these amazing animals. How do we ensure that populations continue to rebound and maintain large enough population sizes to retain the spatial and genetic variability required for resilience to climate change and continued risks to the ocean environment? I have three suggestions. First, develop monitoring plans that are best for identifying large scale impacts to populations, with stronger emphasis on vital rates. Second, look ahead to habitat changes that are likely to lead to shifts in nesting and feeding ground distributions and start working on protections for those areas now. Third, identify funding resources for long term conservation, education and research activities that will continue outside of "crisis mode" while retaining emergency resources for adverse events. Like the turtles we study and protect, we need to take a long-term view – and a sea turtle generation time is very long, indeed!

LINKING OCEANOGRAPHY TO LONG-TERM TRENDS IN FORAGING ECOLOGY AND POPULATION DEMOGRAPHY OF NORTH ATLANTIC LEATHERBACK TURTLES*

Elizabeth Hetherington[1], **Jeffrey A. Seminoff**[2], **Peter H. Dutton**[2], **Brian N. Popp**[3], **Carolyn M. Kurle**[1]

[1]*University of California, San Diego*
[2]*NOAA Southwest Fisheries Science Center*
[3]*University of Hawaii, Manoa*

Evaluating long-term drivers of foraging ecology and its influence on population productivity is crucial for predicting species responses under future climate change scenarios. Here, we present evidence that coarse-scale oceanographic conditions in the North Atlantic (NA) Ocean have contributed to the increase of an endangered leatherback turtle *(Dermochelys coraciaea*) population, and provide insight into long-term trends in leatherback trophic ecology. We analyzed 18 years of blood samples from a well-studied population of leatherbacks nesting on St. Croix, U.S. Virgin Islands for bulk nitrogen (δ15Nbulk) isotope analysis and compound-specific isotope analysis of amino acids (CSIA-AA) to estimate leatherback trophic position, evaluate temporal variability in their feeding ecology, and to better understand their pre-nesting migrations. We found decreases in δ15Nbulk values from 1992-2010 and CSIA-AA revealed that these long-term changes were not due to variations in leatherback trophic position, but instead due to changes in δ15Nbulk at the base of the food chain (i.e., primary producers). Further, our trophic position estimates were comparable to estimates of eastern Pacific leatherbacks from previous studies. We coupled isotope data with nesting information from individual leatherbacks to evaluate the effects of the North Atlantic Oscillation (NAO) and the Atlantic Multidecadal Oscillation (AMO), on trophic ecology and population productivity. We found strong relationships between the δ15Nbulk values from leatherbacks and both oceanographic indices with higher δ15Nbulk values from the turtles associated with positive NAO

and AMO phases. Additionally, we found lower remigration intervals and higher clutch production associated with more positive NAO values, suggesting that the positive phases of the NAO since the early 1990s may have contributed to increases in the North Atlantic leatherback population nesting on St. Croix. We provide evidence that links fluctuations in the NAO to stable isotope biogeochemistry, remigration intervals, and ultimately, population productivity of one population of leatherback turtles. The δ15N values of amino acids also provided insight into the oceanic regions that leatherback utilize prior to arriving in the Caribbean for their nesting season. These data support previous hypotheses which suggest that North Atlantic leatherbacks remigrate to Caribbean nesting beaches from several oceanic areas. Our data have strong implications for leatherback populations, particularly in the North Atlantic, where climate models have predicted a future increase in the positive phase of the NAO.

GENETIC DIFFERENTIATION OF HAWKSBILL TURTLE ROOKERIES AT ST. CROIX, USVI

Jacob E. Hill[1], Courtney King[2], Frank V. Paladino[3], Kelly R. Stewart[4], Peter H. Dutton[4]

[1]*Mississippi State University*
[2]*Miami University*
[3]*Indiana University-Purdue University Fort Wayne*
[4]*NOAA Southwest Fisheries Science Center*

Defining genetically distinct nesting populations of sea turtles is important for the development of management plans and can be used to make inferences about life histories. We collected tissue samples from 41 nesting hawksbill (*Eretmochelys imbricata*) turtles at Sandy Point National Wildlife Refuge, St. Croix, US Virgin Islands to characterize the genetic structure of this rookery in terms of mitochondrial DNA haplotypes. We compared haplotype frequencies from this rookery to previously published haplotype data from Buck Island, another nesting beach on St. Croix, as well as to rookeries across the wider Caribbean. Pairwise F_{ST} comparisons showed that Sandy Point was demographically distinct from Buck Island (F_{ST}=0.501), a finding reinforced by significantly different haplotype frequencies and a lack of interchange of nesting females between both sites based on mark-recapture data. The genetic differentiation between these rookeries was large, despite being separated by a geographic distance of less than 40 km. Sandy Point showed the least differentiation (F_{ST}=0.052) from a rookery more than 2000 km away in Brazil. Divergent ocean currents on the leeward and windward sides of the Lesser Antilles may explain in part genetic connectivity of rookeries separated by vast distances and account for differentiation between nearby rookeries. Our results support the delineation of the nesting populations at Sandy Point and Buck Island into separate units for the purposes of management. Furthermore, mixed-stock analyses that have used Buck Island as representative of the genetic stocks in the Virgin Islands may have underestimated the contribution of USVI rookeries to foraging grounds.

AN ASSESSMENT OF MALE HAWKSBILL SEA TURTLES (*ERETMOCHELYS IMBRICATA*) IN THE NESTING POPULATION OF BUCK ISLAND REEF NATIONAL MONUMENT, ST. CROIX, USVI*

Paul Hillbrand[1,2], Paul Jobsis[1], Alice Stanford[1], Clayton Pollock[2], Zandy Hillis-Starr[2], Kelly R. Stewart[3]

[1]*University of the Virgin Islands*
[2]*National Park Service*
[3]*Ocean Foundation*

Little is known about the number of male sea turtles, especially for Critically Endangered Caribbean hawksbills (*Eretmochelys imbricata*). To gain insight into the life of Caribbean hawksbill males, molecular techniques have been put to use to gather this information. During the female hawksbill monitoring project at Buck Island Reef National Monument (BIRNM) in 2016, which has come to an end, nightly patrols were conducted during which tissue samples were collected from 40 female hawksbills. Tissue samples were also obtained (when possible) from hatchlings that emerged from at least one nest of each of the females (40 nests); this produced 1444 hatchling samples. We compared the genetic identity from tissue samples collected from nesting females and their respective hatchlings using six polymorphic microsatellites. Because there are two alleles at each DNA locus, one belongs to the mother and one to the father therefore, when female and hatchling DNA is compared, the unaccounted-for allele must belong to the father, allowing for breeding adult males to be identified within the population of Buck Island Reef National Monument. In addition, evidence of multiple paternity and an estimation of the operational sex ratio in the Buck Island hawksbill population may be determined. There were no samples taken directly from male hawksbills. Genetic analysis will be conducted at the University of the Virgin Islands as well as at NOAA's Southwest Fisheries Science Center in La Jolla, California. Based on similar studies from Malaysia and the Seychelles we expect a 1:1 adult male to adult female ratio in the BIRNM nesting population and expect there to be evidence of multiple paternity in 10% or fewer of the egg clutches sampled. Male hawksbills are a crucial and critical component in the conservation and management of this Critically Endangered species. Obtaining estimates of the number of males could play a beneficial role in determining how climate change could affect the already skewed female bias that is a common trend in all sea turtle species, due to temperature dependent sex determination (TSD) in the nest. Keeping long-term track of these numbers could help inform us if climate change is in fact allowing for more females to develop in the nests. Or, if not, having knowledge of the male population will be informative for population surveys. Any knowledge that can be gained about hawksbills in the Caribbean will contribute to refining objectives in the recovery plan and restoring these populations.

GENETIC CHARACTERISTICS OF LOGGERHEAD TURTLE IN THE COASTAL CORRIDOR OF THE NORTH WEST PACIFIC, AROUND THE CAPE MUROTO, JAPAN

Takashi Ishihara[1,2], Naoki Kamezaki[1,3], Saya Hirai[2], Yoshimasa Matsuzawa[2], Tomoko Hamabata[4], Asuka Ishizaki[5], Peter H. Dutton[6]

[1]*Suma Aqualife Park Kobe*
[2]*Sea Turtle Association of Japan*
[3]*Okayama University of Science*
[4]*Kyoto University*
[5]*Western Pacific Regional Fishery Management Council*
[6]*National Oceanic and Atmospheric Administration*

To identify and estimate the stock structure of underwater aggregation of North Pacific loggerhead turtle, genetic characteristics of bycaught turtles were determined. Tissues for identification of their haplotype were gathered from juvenile, subadult and adult turtles which bycaught in pound net in Muroto, Kochi, Japan from 2005 to 2010 except 2007. In each year of the 5 years term, 100 samples were processed and sequenced to generate approximately 820bp of mitochondrial DNA, respectively. Straight carapace length of the turtles range 56.3– 99.1 cm and their life stage were identified based on the size at puberty (66.0cm) and maturity (82.1cm). A total of 487 out of the 500 samples yielded sequences of sufficient quality to identify 5 different haplotypes. We conducted mixed stock analysis (MSA) in order to estimate nesting stock contributions to the Muroto foraging population with Bayesian approaches. Unweighted and weighted priors were used to run MSA. In the weighted priors, which take into account the relative nesting number of each potential source nesting population or management unit (MU). However, the MSA estimates were similar for models using unweighted and weighted priors. Then, there was no significant difference between haplotype frequencies among the different size classes and life stages, nor among the different years, therefore the haplotype frequencies were combined for the MSA. Although 95% CI was large, approximately 97 % of the turtles originated from the Yakushima MU and Mainland MU, with a minor estimated contribution from Ryukyu MU. Comparison with the proportion of regional nesting numbers in each MU, the estimated proportion of Ryukyu origin turtles was lower but that of Yakushima MU origin turtles was higher in the Muroto foraging aggregation. The reason for this proportion shift would be related to the distance from the natal area. Cape Muroto is located in the vicinity of the Mainland MU rookeries, 400-500 km apart from Yakushima MU rookery, and 650-1400 km apart from Ryukyu MU rookeries, thus the origin of Mainland rookeries increased relative proportions and origin from Ryukyu rookeries decreased vice versa. It is highly likely that immature loggerheads that migrate to Japanese waters have the tendency to utilize foraging grounds and migration routes near their natal waters.

AGE ESTIMATION OF JUVENILES GREEN TURTLE CHELONIA MYDAS AT URUGUAYAN COAST

Leila Joaquin[1], Gabriela M. Vélez-Rubio[2,3], Andrés Estrades[2], Alejandro Fallabrino[2], Mario R. Cabrera[1]

[1]Cátedra de Anatomía Comparada. UNC. Av. Vélez Sarsfield 299, Cordoba, Argentina
[2]Karumbé, Av. Rivera 3245, Montevideo, Uruguay
[3]Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Aptdo. 22085, E-46071 Valencia, Spain

The Uruguayan coast is an important feeding and development area for green turtles (*Chelonia mydas*) during the juvenile neritic stage of their life cycle in the South Western Atlantic Ocean. The present study seeks to contribute with basic data on the demographic structure of the green turtle aggregation that use those coastal waters. Since 2001 the NGO Karumbé has conducted seasonal beach surveys along the Atlantic coast of Uruguay, looking for live and dead stranded turtles to record different biometric data and collect tissue samples. The objective of this study is to obtain an age estimation of the *C. mydas* individuals according to turtle size at Uruguayan feeding grounds, using skeletochronology method. The fieldwork was carried out along the Uruguayan coast including the Departments of Canelones, Maldonado and Rocha. The right humeri of dead stranded turtles were removed using a scalpel. After that, the bones were cleaned and macerated in water, washed and dried outdoors. For this study, 86 humerus were collected during different surveys from 2002 to 2013 of the dead stranded turtles found in different decomposition stages. They present a mean Curved Carapace Length (CCL) of 38.3±4.9 cm (range 27.7 to 51.0 cm), with the most frequent size range between 36.0 and 42.4 cm. Using an electric saw, a 5 to 8 mm thick cross-section was obtained, applying the histological technique for permanent preparations with hematoxylin and eosin staining. Nine cuts were discarded as they lacked clarity under the microscope caused by breakage or technical defect. The remaining 77 specimens presented 0 to 5 lines of arrested growth (LAGs). If each LAG represents a one year-period we can infer that the turtles were between one to five years. Most turtles were only one or two years old. The LAGs could be visualized only on those turtles that reached at least a size of 29.9 cm of CCL, on which the first growth mark was verified. This data ascertained an exploratory analysis of the growth data that could help us to infer the recruitment age of *C. mydas* to Uruguayan neritic grounds. Also help us to understand the distribution of the species in their earlier stages in the western South Atlantic.

LIFE HISTORY AND DEMOGRAPHY OF A NESTING POPULATION OF LEATHERBACK SEA TURTLES (*DERMOCHELYS CORIACEA*) AT ST. CROIX, U. S. VIRGIN ISLANDS, 1992-2013*

William Kendall[1], Kristen Pearson[1], Peter H. Dutton[2], Kelly R. Stewart[2], Claudia Lombard[3], Jennifer Valiulus[4]

[1]*USGS Colorado Cooperative Fish and Wildlife Research Unit*
[2]*NOAA Southwest Fisheries Science Center*
[3]*USFWS Sandy Point and Green Cay National Wildlife Refuges*
[4]*St. Croix Environmental Association*

Knowledge of the population dynamics and vital rates of the endangered leatherback sea turtle (*Dermochelys coriacea*), especially as a function of exogenous and endogenous factors, is important to the conservation of this species, and to the study of long-lived taxa in general. The adult female life stage is both an important contributor to population growth, and the most accessible to study. The nesting population of leatherbacks at Sandy Point National Wildlife Refuge, at St. Croix, U. S. Virgin Islands, has been studied via a saturation tagging program since 1982, with the use of PIT tags beginning in 1992. We used captures of individual females from 1992 to 2013, and the multistate open robust design method, to model population dynamics of adult females (nesters and total females), and annual survival and remigration probabilities. For each year we modeled arrival date, renesting probability, and clutch frequency, in the face of imperfect detection. We partitioned captures into neophytes and remigrants. We hypothesized that there could be a transient effect on neophyte survival, and that remigration probability and clutch frequency would be lower for neophytes. In addition, we hypothesized that remigration probability would increase with each successive year that breeding was skipped. We found that the increase in population size in the 1990s, reported in an earlier publication, stabilized beginning in 2000, at under 500 turtles, with the proportion of females nesting in a given year at an average of 0.43. The most parsimonious model included a constant survival rate of 0.90, whereas apparent survival for neophytes was 0.82, indicating a transient effect. Overall remigration probability fluctuated but without trend. Nesting in two consecutive years was rare. There was some evidence remigration probability increased when successive breeding years were skipped, but it was weak. However, remigration probability was substantially greater for remigrants than for neophytes. The same was true for clutch frequency, and neophytes arrived later than remigrants. Capture probability for each 9-day interval ranged from 0.55-0.78, but the probability of being captured at least once in a season was close to 1.0. These results over 22 years are consistent with improving status of leatherbacks in the Caribbean, and given their nesting beach is protected, this study provides a benchmark for survival of adult female leatherbacks.

EMERGENCE SUCCESS VARIATION IN GREEN SEA TURTLE *CHELONIA MYDAS* NESTS ON DIFFERENT KEY NESTING BEACHES IN CHICHI-JIMA, OGASAWARA, JAPAN, 2010-2016

Satomi Kondo[1], Yukari Morimoto[1], Takayuki Sato[1], Hiroyuki Suganuma[1]

[1]*Everlasting Nature of Asia*

The Ogasawara Islands are the largest green sea turtle *Chelonia mydas* rookery in the north Pacific. There are 41 nesting beaches in the largest island group, Chichi-jima within 36.8km². Number of nests, hatchling

production, hatching and emergence success, and sources of egg mortality in green sea turtle in-situ nests of 2010 to 2016 nesting seasons in Chichi-jima were determined in this study. Then, nine key nesting beaches were chosen to be assessed individually. A total of 11,336 nests were examined and 263,747 hatchlings were produced in Chichi-jima. Annual mean emergence success were 36.8±3.4%, which are relatively low compared to other major green rookeries. Depredation by ghost crabs *Ocypode cordimanus* is the most important cause of egg mortality during incubation followed by ants. Annually 52.8±3.9% of nests were disturbed by ghost crabs and it becomes 77.6±10.0% in the most nested beach alone. The variation in emergence rates between years for a single nesting beach was significant. A maximum difference of emergence rates between sample years for single nesting beaches ranged 12.7%-33.6%, although there was only 9.6% of year difference in emergence success for the overall study site. The beach which hosted the most nests possessed 15.0% of annual mean nest number in Chichi-jima. Nest contribution of each beach was relatively small, which indicates that selection of nesting beach by female turtles has not been concentrated in a single site. This may result in a small fluctuation of overall emergence rate between years despite of much greater fluctuation in a single beach. Besides, this might be due to the unique geographical feature of Ogasawara Islands as nesting beaches are interspersed within a narrow area. Total annual nest numbers were correlated with emergence success for the sample years (r=0.87). However, there is no correlation between those numbers for 8 years from 1983-1990 in the same study location (r=0.20). This difference may be attributed to a remarkable increase of nest numbers in the past decade, as the annual mean number of nests is 262.5±103.2 from 1983- 1990, whereas 1445.0±636.9 nests between 2010-2016. Moreover, the most annual number of nests, which was 2,663 nests, and hatching production were recorded in 2016. This implies that the emergence rates are stable under the recent increased number of nests. Even though annual emergence success in the study area was consistently low during sample years as well as 1983-1990 (32.2±6.8%), the turtle population has shown a remarkable increase trend. This study indicates that the significant variations in hatching and emergence success among nesting beaches, suggesting a single or a couple of survey location would not reflect population status of nesters and hatchling production within a rookery. Furthermore, the stable emergence success correlated with the nest numbers may be an important criterion to assess future population of green turtle in Chichi-jima, where is geologically distinctive as a rookery.

PROMISCUITY TO PUSH FOR EVOLUTIONARY STABILITY?

Jacob Lasala[1], Colin Hughes[1], Jeanette Wyneken[1]

[1]*Florida Atlantic University*

The recovery of endangered marine turtles is complicated by the need for simple and effective methods of quantifying individuals. If the population is difficult to access, its behavior is elusive, or some individuals are widely observable while others are cryptic, a census count is ineffective. Sex ratios, population size, and relatedness of individuals are important metrics of population status, to ascertain how a population is progressing. For marine turtles, hatchling sex ratios are estimated through patterns of environmentally-driven sex determination (TSD) and in Florida these frequently reflect a female bias. Adult sex ratios are primarily estimated through counts of nesting females; however, this method leaves the number of adult males to be enigmatic. Alternative assessment techniques include using molecular (genetic) markers to identify parentage of individuals as well as fundamental relationships among males and females within a population. By comparing maternal genotypes to offspring genotypes (exclusion analysis), male numbers can be estimated with much greater accuracy, and those results can be applied to estimate effective population size. We compared the numbers of males and females contributing to green sea turtles (*Chelonia mydas*) and leatherback turtles (*Dermochelys coriacea*) nesting populations in southern Florida and determined that these species are promiscuous (multiple paternity of clutches was common). However, we

did not find repeating males, suggesting that the number of males may be higher than previously expected based on hatchling sex ratio estimates. High occurrence of multiple paternity could signal an evolutionary shift to buffer against changing population sex ratios even as temperatures continue to rise.

NATAL-HOMING AND POPULATION STRUCTURING OF HAWKSBILL TURTLES IN THE NORTHEASTERN CARIBBEAN

Kathryn Levasseur[1], Seth P. Stapleton[2], Mykl Clovis Fuller[3], Joseph M. Quattro[1]

[1]University of South Carolina
[2]Jumby Bay Hawksbill Project
[3]Antigua Sea Turtle Conservation Project

Marine turtles migrate back to their natal region during reproduction, but the precision of this homing behavior and whether the precision varies within a species or across regions is unclear. We analyze new mitochondrial haplotype data from hawksbill turtles (*Eretmochelys imbricata*) at several nesting sites across Antigua and Barbuda to better characterize genetic diversity at this sister-island nation and to assess the scale of natal-homing across islands separated by 40 kilometers. We then combine these data with published haplotype data from Western Atlantic rookeries to examine patterns of population structure across the region. Antiguan and Barbudan nesting sites were remarkably differentiated for their proximity, suggesting that these hawksbills are homing with high precision and that the two islands should be considered separate management units. Nesting sites within the island of Antigua, separated by an average of 25km, also showed some structuring with respect to haplotype frequencies. Regionally, we found stronger population differentiation among the rookeries of the Lesser Antilles than among those of the Greater Antilles and continents despite their smaller geographical range. This supports the hypothesis that rookeries on small, isolated land masses have more genetic structuring (i.e. natal homing to a finer scale) than rookeries on large, continuous land masses. Further, we hypothesize that hawksbills nesting on small, isolated islands may be more threatened by dynamic coastlines than hawksbills nesting on larger land masses due to their strong natal-homing precision, high nest-site fidelity, and thus reduced ability to colonize new nesting sites.

AGE AND GROWTH RATES OF NEWLY RECRUITED JUVENILE GREEN TURTLES IN THE NEARSHORE WATERS OF THE HAWAIIAN ARCHIPELAGO

Shawn K. K. Murakawa[1], Madeline Schuldt[2], Summer L. Martin[1], T. Todd Jones[1]

[1]NOAA Fisheries, Pacific Islands Fisheries Science Center, Marine Turtle Biology and Assessment Program, Honolulu, Hawaii, USA
[2]Bowdoin College

While adult breeding grounds and foraging habitats of green sea turtles have been well documented through observation and satellite biotelemetry, early juvenile habitats and residency times remain poorly understood. Green turtle hatchlings leave the nesting beaches of the Northwestern Hawaiian Islands and are generally not seen again until they recruit to the neritic benthic waters of the Main Hawaiian Islands (MHI; Hawaii, Maui Nui Complex, Oahu, and Kauai) as small juveniles (≤ 35 cm carapace length). Skeletochronology techniques were used to section humerus bones from juvenile green turtles collected through the Pacific Islands Fisheries Science Center (PIFSC) Marine Turtle Biology and Assessment Program's stranding network. These nine turtles ranged from 29.8 – 35.2 cm straight carapace length. All

turtles had at least 2 lines of arrested growth (LAGs) and the minimum estimated age of the turtles ranged from 2 - 4 years. The average resorption core represented 51.4% of the section implying that the age of the turtle could possibly be double the number of LAGs present. The average growth rate for the 9 turtles was 2.51 cm•yr-1. There was a marked shift in growth as the highest growth rate (0.21 – 10.92 cm•yr-1) was found in the first set of LAGs immediately following the resorption core and was an order of magnitude greater than the following (more recent) LAGs. This suggests that the turtles may have recently recruited to the nearshore habitat with a concomitant dietary shift leading to the reduced growth rates. Oceanic diet of juvenile greens consists of mostly animal matter and as they switch to the neritic phase they switch to a mostly benthic algae diet. Information on the early growth rates, age at recruitment, and residency times will help to elucidate the early ecology of green turtles. Ultimately, the study will improve our understanding of stage specific growth rates and residency times of green turtles and how these changes affect age to maturity and reproductive output.

ECOLOGY AND NESTING STATUS OF THE SEA TURTLES OF THE AYEYARWADY REGION, MYANMAR WITH A CASE STUDY OF THE OLIVE RIDLEY

Ko Myint[1], Maung Maung Lwin[2], Win Maung[1]

[1]University of Yangon
[2]Myanmar Department of Fisheries

The nesting status of *Chelonia mydas* (Green turtle) and *Lepidochelys olivacea* (Olive ridley turtle) associated with ecological factors were studied on the islands of Thameehla at 15° 51′N, 94 º 17′E (a wildlife sanctuary), Kadongalay at 15° 40′ 50"" N and 95° 16′ 16"" E and Gayetgyi at 15° 41′ 11"" N and 95° 14 51""E (non-protected islands). Maxwell (1911) reported that several thousand sea turtles came to nest annually on these islands at that time. This study focused on recent nesting activities, to identify habitat conditions and threats as well as to develop conservation measures. The nesting turtles were tagged using flipper and PIT tags. Green nesting was recorded throughout the year on Thameehla Island with August to October peaks while Olive ridley nesting occurred during September to February with a peak in January on the islands of Kadongalay and Gayetgyi. The maximum nesting frequency recorded for Greens was 4 (n=16) with two-three-week intervals and the average clutch size of 92. The typical nesting frequency was 2-3. Olive ridleys were recorded up to 3 times (n=14) but predominantly 2 times with two-week intervals and an average clutch size of 110. Nesting preferences depended on the state of tide, sand type, and weather conditions. Both species nested more commonly during spring tide rather than neap tide. Greens preferred calcareous sand for nesting while Olive ridleys preferred siliceous sand. Nesting activity of Greens was recorded mostly in the rainy season from August to October with ambient temperature ranging from 27-32 °C while Olive ridleys were found nesting actively during winter season (December to January) with an ambient temperature range of 22-29 °C. In 2006--2007 on Thameehla Island the number of recorded nests of the Greens was 305 (estimated nesters: =< 150) which dropped steadily to 150 nests in 2015-2016 (estimated =<70), a reduction of nearly 50% within one decade. A total of 115 Olive ridley nests (estimated =< 60) was recorded on Kadongalay and Gayetgyi Islands during 2005-2006 while that number dropped precipitously to 11 nests in 2015-2016 (estimated turtles =<10), a reduction of about 95% within one decade. This result suggests more anthropogenic pressure on the Olives than Greens. A continuous study of Olive ridleys from 2014 to 2016 revealed a 59% drop in nests in 2015 (27 nests) to 2016 (11 nests). Identified threats include large scale trawl-fishing and harmful bottom-bag nets with illegal egg poaching on some beaches. Turtle Excluder Devices (TEDs) are not now used but are strongly recommended for use in any trawl-fishing-nets. A TED use policy needs urgent development to improve marine turtle conservation in our waters. Improved awareness of the threats, education and law enforcement are considered key effective needs to reduce negative impacts on turtles. Finally, Kadongalay and Gayetgyi

Islands should have full protection under the law and need strong coordination between government, INGOs, NGOs, and Universities to achieve sustainability.

NEXT-GENERATION ENVIRONMENTAL DNA TECHNOLOGY: APPLICATIONS FOR AQUATIC CONSERVATION BIOLOGY

Eugenia Naro-Maciel[1], Jennifer Servis[2,3], Patrick Shea[4,5], Irena Werner[4,5], Seth Wollney[4]

[1]New York University
[2]U.S. Fish and Wildlife Service
[3]The Graduate Center
[4]City University of New York
[5]College of Staten Island

Environmental DNA (eDNA), or DNA sequenced directly from water, soil, fecal, or other mixed samples, represents a novel and transformative technology for assessing and monitoring biodiversity. Next-generation high-throughput sequencing has numerous advantages, including furnishing voluminous data from readily available samples, such as water, and improving representation of cryptic or elusive organisms. Turtles and their communities, however, remain relatively understudied in this new field. This presentation therefore aims to: 1) Provide an overview of aquatic eDNA research; 2) Discuss turtle detection using generalized eDNA approaches at our aquatic study sites, and in the literature; and 3) Offer suggestions for incorporating eDNA analysis into research of sea turtles and their ecosystems. Although the first step in any ecological assessment is correct organismal identification, marine turtles may be difficult to detect in some cases, such as during the cryptic "lost years". So far, general eDNA approaches (using universal 18S rRNA eukaryotic primers for amplification), though increasingly useful for biomonitoring, have not served as a panacea for detecting turtles. The published literature reveals that such broad-scope methods have fallen short in attempts to corroborate known turtle presence in aquaria and other areas. In our own work on coral reefs of Palmyra Atoll, Central Pacific, neither hawksbill nor green turtles were detected with these primers, despite their known presence. In a river and various freshwater ponds along an urbanization mosaic in New York City, while numerous turtles from three species were observed, only three hits from the red-eared slider turtle were recovered, even after sequencing 10 static replicates. This indicates that, although increasing the number of polymerase chain reaction (PCR) replicates can enhance coverage of rare organisms detected with a universal primer, it does not fully compensate for primer selection. A more refined methodology has shown promise in the literature for detecting turtles, particularly through the use of quantitative PCR (qPCR) and more highly-targeted primers, which can be tested in silico prior to costly lab work. Perhaps the greatest value of eDNA lies in characterizing communities rapidly and effectively. The intense research focus on marine turtles, although essential, has sometimes taken away from their consideration in an ecosystem context. Conservation efforts are increasingly moving towards more comprehensive ecosystem-level approaches. Thus we are using eDNA to gather baseline information and describe communities of Palmyra and urban freshwater areas. In this approach food webs may be investigated, illuminating aspects of diet and community structure, and keystone species or ecosystem health indicators can be targeted. Limitations, such as technical issues including fragment length, contamination, error risk, a dearth of comprehensive reference databases, as well as capture, laboratory, computational, and data storage challenges, are being addressed. The ideal methodology will ultimately depend on the project's goal, and different primers can be used to amplify a target organism, or for community analysis. The innovative eDNA technology now offers rapid, effective, and standardized methods to complement traditionally gathered data for comprehensive management and monitoring through improved biodiversity information.

MONITORING STRATEGY EVALUATION: A NEW TOOL TO IMPROVE MONITORING AND STATUS DETERMINATIONS FOR SEA TURTLES*

Susan E. Piacenza[1], Paul Richards[2], Selina S. Heppell[3]

[1]*Occidental College*
[2]*NOAA - SWFSC*
[3]*Oregon State University*

Population monitoring must be accurate and reliable to correctly classify population status. Green sea turtles, *Chelonia mydas*, have endangered and threatened populations globally, but several nesting beaches have shown substantial increases in the number of nests or nesting females. Sea turtle nesting beach surveys are commonly used as a population index for assessment because nesting turtles are easily accessed and quantified. However, this is problematic because process and observation errors, compounded by delayed maturity, obscure the relationship between trends on the nesting beach and the population as a whole. We present a new simulation-based tool, Monitoring Strategy Evaluation (MoSE), to explore the relationships between monitoring data and assessment accuracy. Like its predecessor, Management Strategy Evaluation, MoSE has three main components: the simulated "true" operating model (an agent-based virtual population of sea turtles), an observation model, and an estimation model. To explore this first use of MoSE, we apply different treatments of population impacts, sampling, and detection of the virtual "true" population, and then sample the nests or nesters to test if the observation "data" accurately diagnose population status indicators. Based on the observed data, we estimate adult abundance, nester recruitment, and population trend and compare these indices to the known values from the operating model (virtual "true" population). We ran a series of scenarios with different process and measurement errors, including harvest impacts, cyclical breeding probability, sampling biases, constant and annual demographic parameters, and varying monitoring durations to see how these realistic factors impact accuracy in estimating status indicators. We found that disturbance type and severity have important and persistent effects on the accuracy of population assessments drawn from monitoring rookeries. In general, nest counts are poor indicators of population status when realistic environmental variability and measurement error are included in the model. Accuracy in abundance estimates may be most improved by avoiding clutch frequency bias in sampling and including annually varying (versus constant) breeding probability, detection probability, and clutch frequency in the estimation model. Accuracy of nester recruitment may be most improved by increasing detection level and avoiding age-bias in sampling. The accuracy of estimating population trend is influenced by the underlying population trajectory, age classes disturbed, and disturbance severity. At least 10 years of monitoring data are necessary to accurately estimate population trend, and longer if juvenile age classes were disturbed and trend estimates occur during the recovery phase. Unexpectedly, increasing detection only improved accuracy in estimating recruitment, but not abundance or population trend. Ultimately, it is important to carefully consider the impact history, and specifically which age classes were disturbed, when developing a monitoring program and interpreting population indices drawn from rookeries. Future work will include expanding MoSE to be spatially explicit and making the climate variability submodel more realistic. The MoSE is an important tool for sea turtle biologists and conservation managers because it allows biologists to make informed decisions regarding the best monitoring strategies to employ for sea turtles.

SATELLITE TRACKING OF HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) IN NORTHERN PERU

Sergio Arturo Pingo Paiva[1], Astrid Carolina Jimenez Heredia[1], Jeffrey C. Mangel[2], Joanna Alfaro-Shigueto[1], Nicolas Acuña-Perales[1]

[1]ProDelphinus, Lima, Peru
[2]University of Exeter, Cornwall, UK

Hawksbill turtles (*Eretmochelys imbricata*) are a globally endangered species with populations in the eastern Pacific Ocean identified as particularly threatened. Since 2011 we have monitored the incidental capture of *E. imbricata* in the small-scale gillnet fishery in Sechura Bay, Piura, northern Peru, and in the last three years we have used satellite telemetry to record movements of individuals. Since 2014 nine juvenile individuals were tagged, with an average curved carapace length 43.6 ± 1.6 cm (CCL max; range: 36.0 to 49.8 cm). Tracking durations range from 18 to 489 days, with 4 PTTs still active. The monitoring show that seven individuals stayed in Sechura Bay and two departed the bay: one travelled west past the Galapagos Island (distance travelled =1880 km, displacement = 1379 km); and one travelling north into coastal Ecuador (distance travelled = 1570 km, displacement = 474 km). The individuals that remained in Sechura Bay stayed coastal (approximately 1 km or less from shore), they travelled to the south of the Bay only, the displacement of these individuals was 6.5 ± 1.7 km and the average distance traveled was 199.4 ± 95.5 km. One tracked individual was recaptured by fishermen and released. Our results suggest that Sechura Bay is an important foraging and developmental area for juvenile *E. imbricata* in the southeast Pacific and continues to provide valuable information about habitat use and fishery interactions in northern Peru and southern Ecuador. Given these insights, we recommend strengthening regional monitoring programs, local awareness raising campaigns, and management and protection of critical areas to achieve improved hawksbill conservation in the Eastern Pacific.

A TALE OF TWO OCEANS: META-ANALYSIS OF ADULT MARINE TURTLE SURVIVAL RATES

Joseph B. Pfaller[1,2], Milani Chaloupka[3,4], Kristina L. Williams[1], Alan B. Bolten[2], Karen A. Bjorndal[2]

[1]Caretta Research Project, Savannah, GA, USA
[2]Archie Carr Center for Sea Turtle Research
[3]University of Florida, Gainesville, FL, USA
[4]Ecological Modeling Services and University of Queensland, St. Lucia, Queensland, Australia

Quantifying accurate estimates of adult survival for marine turtles is critical for the conservation and management of marine turtle populations, as estimates allow managers to assess population stability, investigate declines, and evaluate management effectiveness. However, current estimates of annual survival probability for adult marine turtles are highly variable and many estimates are far lower than expected for animals that take between one and four decades to reach sexual maturity. We conducted a literature review and meta-analysis to better understand the individual and synergistic effects of methodological and statistical biases, as well as other population- or study-specific factors, on the accuracy and precision of adult survival estimates. A total of 75 annual survival estimates for adult marine turtles was found in the literature review and 59 met the selection criteria for inclusion in the final meta-analysis. The best-fit model based on AICc from a multilevel mixed-effects meta-regression accounted for 49% of

the variation and included six predictors: species, ocean, model type, habitat, population trend and duration. We expect the findings of this synthesis to directly inform the methods and models by which annual survival probability is estimated in adult marine turtles, thereby improving our ability to make accurate assessments of the status and trends in marine turtle populations worldwide.

COMPARISON OF KEMP'S RIDLEY SEA TURTLE SOMATIC GROWTH RATES BEFORE AND AFTER THE DEEPWATER HORIZON OIL SPILL

Matthew D. Ramirez[1], Larisa Avens[1], Lisa R. Goshe[1], Selina S. Heppell[1]

[1]*Oregon State University, Corvallis, Oregon, USA*

Assessment of species population dynamics requires a comprehensive understanding of spatiotemporal variability in demographic parameters, and the factors that regulate them. Changes in growth and survival are particularly influential to the recovery of long-lived species because small changes in these and other vital rates can strongly influence species population dynamics. Following the Deepwater Horizon (DWH) oil spill, multiple studies have documented negative effects on a wide range of marine taxa, but impacts on long-lived marine species are less clear. Beginning in 2010, the year of the DWH oil spill, the Kemp's ridley sea turtle (*Lepidochelys kempii*) experienced a dramatic, multi-year reduction in population growth rate. Nest counts returned to pre-2010 levels in 2016, but the extent to which the DWH oil spill contributed to this reduction has yet to be determined due to the lack of pre-DWH data for most demographic parameters. We can obtain some of this information through quantification of short- and long-term changes in somatic growth and age at maturation before, during, and after the oil spill. We are currently using skeletochronology to quantify Kemp's ridley sea turtle growth rates and age and size at maturation in the Gulf of Mexico following the DWH oil spill (2010 – 2016) to compare with the same data from bones analyzed prior to the spill (1993 – 2010). Humerus bones (n = 461) were collected through the Sea Turtle Stranding and Salvage Network (STSSN) from dead stranded turtles in U.S. Gulf coast states. Standard methods were used to perform skeletochronological analyses and estimate annual growth rates and age and size at maturation. Ongoing analyses will use Generalized Additive Mixed Models and repeated measures ANOVA to quantify short- and long-term changes in Kemp's ridley sea turtle somatic growth rates and maturation through time, and to compare growth patterns among size classes, sexes, and stranding locations. Updated somatic growth information following the DWH oil spill will fill knowledge gaps critical to population modeling and management efforts, and will assist in oil spill impact assessments.

AN EYE IN THE SKY IS BETTER THAN BODIES IN THE BOAT: USE OF UAV DRONES TO COUNT TURTLES AND DETERMINE THE OPERATIONAL SEX RATIO AT A MAJOR BREEDING GROUND ON THE GREAT BARRIER REEF*

Richard Reina[1]

[1]*Monash University*

Undertaking population surveys of turtles at sea at foraging grounds, breeding grounds or elsewhere is generally expensive and time-consuming because they must be done using boats. However, in recent years commercially-available unmanned aerial vehicles (UAVs or drones) have become cheaper, more reliable and easier to operate. They offer the advantage of being able to continuously record high-quality video over a large area during aerial transects, with less disturbance to animals and a better vantage point than

boats. I used an inexpensive commercial drone (Phantom 3) to survey and sex turtles present in the waters around Heron Island on the Great Barrier Reef to calculate the Operational Sex Ratio (ratio of reproductively active males and females). I compared the results of over 20 drone surveys with those of about 25 hours of boat surveys at the same location. Results show that it is easy to distinguish mature males and females from the air and that turtles do not appear to be disturbed by the presence of the drone. I observed about 200 turtles during the boat and drone surveys combined. The Operational Sex Ratio was approximately 1:1 (males:females) early in the breeding season but was about 1:7 later in the breeding season, indicating that most males do not remain at the breeding grounds after nesting commenced. Drones were efficient at covering transects, with about 3.5 to 5 km surveyed each 20-minute flight. In contrast, boat surveys were more time consuming, expensive and limited to parts of the tidal cycle when water was sufficiently deep to enter inside the reef crest of the lagoon surrounding Heron Island. In this presentation I will explain how UAV technology works, how it can be used in a variety of relevant situations and explain the benefits of using UAVs compared to more traditional at-sea techniques. I will compare the efficiency and results obtained from UAV and boat surveys to contrast their effectiveness at counting turtles and determining their sex. I will present a video to show the technique in action, so that those without experience can see how it can be successfully applied to their own situation.

DIE ANOTHER DAY; GROWTH MODEL REVEALS HIGH NATURAL SURVIVAL IN LOGGERHEAD SEA TURTLES*

Leslie Schroeder[1], Larisa Avens[2], Lisa R. Goshe[2], Karen A. Bjorndal[3], Alan B. Bolten[3], Paul Venturelli[1]

[1]University of Minnesota- Twin Cities
[2]National Marine Fisheries Service, NOAA Beaufort Laboratory
[3]University of Florida- Gainesville

Accurate life history parameters are essential to effective management. Population growth greatly depends on adult survival rates which are usually estimated via mark-recapture, but may be inflated by emigration, tag loss, and anthropogenic mortality. Using the Lester Growth Model, un-confounded natural survival, the survival rate that adults experience independent of human influence, can be estimated from the change in growth rate that occurs with maturity. This model is based on the theory that investment in reproduction is an evolved trait that trades off with natural mortality. In general, adults invest in reproduction at the expense of growth and survival. The degree to which adult growth slows relative to immature growth in the Lester Growth Model is indicative of investment in reproduction and therefore natural mortality rate. We used the Lester model to estimate sex-specific natural survival rates from length-at-age and maturity data for the western North Atlantic population of loggerheads. Both male and female annual natural survival rates were estimated to be 96-97%. This is a first-time estimate of survival for males, which do not come ashore for nesting, and are therefore overlooked by most mark-recapture studies. Our life history-based survival estimates are 10-20% higher than those in the published literature. Given that the "true" value of natural survival is unknown, we incorporated published life history traits into a matrix model to estimate a range of possible adult survival rates. Matrix and growth model results were in strong agreement. Assuming negligible emigration or tag loss, the discrepancy between our survival estimates and those in the literature are due to anthropogenic mortality. If annual adult survival is 96-97%, then this population of loggerhead sea turtles has a "slower" life history than previously thought, and is therefore less resilient to additional mortality. Accurate estimates of natural survival are important to the development of population models and sea turtle conservation in general. The Lester Growth model has been used to estimate the natural survival rate of bony fishes, sharks, and now loggerheads; and can likely contribute to the conservation of other populations or species of sea turtles.

REPRODUCTIVE OUTPUT OF HYBRID SEA TURTLES AND PARENTAL SPECIES*

Luciano S. Soares[1], Alan B. Bolten[1], Marta L. Wayne[2], Sibelle T. Vilaça[3,4], Fabrício R. Santos[5], Maria A. G. dei Marcovaldi[6,7], Karen A. Bjorndal[1]

[1]Archie Carr Center for Sea Turtle Research, Department of Biology, University of Florida, Gainesville FL, USA
[2]Genetics Institute Department of Biology, University of Florida Gainesville, FL, USA.
[3]Leibniz Institute for Zoo and Wildlife Research (IZW), Department of Evolutionary Genetics, Berlin
[4]Center for Genomics in Biodiversity Research (BeGenDiv), Berlin, Germany
[5]Laboratório de Biodiversidade e Evolução Molecular (LBEM) Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, MG, Brazil
[6]Projeto TAMAR, ICMBio
[7]Fundação Pró-TAMAR, Salvador, BA, Brazil

Sea turtle hybridization is a global phenomenon known to occur at very low incidence. The exception to this is found in Brazil, especially between the hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*) populations nesting in the northeastern coast. Hybrid females have been reported at an impressive 42% rate among morphologically assigned hawksbills. Hybridization may affect vertebrate taxa in different ways. Hybrids may present hybrid vigor, lower fitness or show no reproductive output advantage or disadvantage. So, what are the consequences for these sea turtle hybrids in Brazil? Here we present the first analysis of the effect of hybridization on the reproductive output of sea turtle hybrids. We assigned a status of hawksbill, loggerhead, or hybrid to 146 females through the analyses of nuclear and mitochondrial markers. We analyzed several reproductive parameters: female curved carapace length, clutch size, emergence success, incubation period, hatchling production, observed clutch frequency and observed breeding frequency. Based on these, hybrids do not appear to be at either a reproductive advantage or disadvantage relative to their parental species. Although emergence success is lower in hybrids, hatchling production per clutch, as well as clutch frequency and breeding frequency, are similar among the three groups. These results show that hybrids may persist in this region. This hybridization phenomenon observed in Brazil could be of evolutionary importance and requires long term monitoring of this population. Further research on hybrid survival rates at different life stages, as well as growth rates and their ecological roles will be fundamental to predict the fate of hybrid turtles. We suggest that sea turtle populations that overlap with other sea turtle species in space and time on nesting beaches be screened for hybridization with the appropriate genetic markers.

UNTANGLING NEARSHORE SEA TURTLE DENSITIES: UAS APPLICATIONS FOR POPULATION ASSESSMENTS*

Seth Sykora-Bodie[1], Vanessa Bezy[2], David Johnston[1], Everette Newton[1], Kenneth J. Lohmann[2]

[1]Duke University Marine Lab, Beaufort, North Carolina, USA
[2]University of North Carolina, Chapel Hill, North Carolina, USA

Marine turtles face significant pressure from a variety of human activities including commercial fishing, egg poaching, and habitat destruction. Although these threats have resulted in substantial population declines globally, many populations are stabilizing or even beginning to recover in response to reductions in fisheries bycatch, investments in conservation programs, and international bans on the trade of turtle

products. While these improvements are encouraging, the status of many populations remains unknown and continued scientific monitoring is therefore needed to inform conservation and management decisions. To help address these gaps, this study presents new methods for utilizing unmanned aerial systems (UAS) to conduct at-sea population assessments. Utilizing a fixed-wing UAS and a modified strip-transect method, we conducted aerial surveys along a three-kilometer track line perpendicular to the shore at Ostional, Costa Rica during an olive ridley turtle (*Lepidochelys olivacea*) mass-nesting event in August 2015. We visually assessed near-infrared images collected during six transects for sea turtle presence, resulting in 682 certain detections and 1091 total detections (probable and certain) in near-surface waters. We then used these detections to calculate estimates of sea turtle density km-2 in the nearshore waters of Ostional. After adjusting for both availability and perception biases, we developed a low-end estimate of 623 ± 220 and a high-end estimate of 1000 ± 385 turtles per km-2. This pilot study illustrates how UAS can be used for at-sea marine turtle population studies, providing a robust, safe, and cost-effective approach that may be more practical than traditional methods of calculating density estimates in coastal areas. Further research is required to determine best practices for sampling strategies in long-term studies aiming to estimate seasonal and annual trends in density. Our results indicate that UAS-based survey approaches will provide significant insights into the offshore geographic distribution of many marine turtle populations.

SEA TURTLE MITOCHONDRIAL DNA HETEROPLASMY: AN EVOLUTIONARY POINT OF VIEW

Yaron Tickochinski[1]

[1]*Ruppin Academic Center*

Most of genetic population analysis in sea turtles is made by using the Mitochondrial DNA (mtDNA) D-loop sequencing. Mitochondrial DNA inheritance is very different than chromosomal inheritance. While an organism gets only one set of chromosomes from each parent, it starts its life with a few thousands molecules of mtDNA, almost exclusively from its mother. These molecules are not necessarily identical, a phenomenon termed heteroplasmy. Using the Illumina high throughput sequencing, we were able to look at the D-loop region of tens of thousands of mtDNA molecules per sample in 200 sea turtles of 4 species. We have discovered a heteroplasmy ranging from 5% and up to 15% in all of the samples. The rate of mutations in the mtDNA repeat region was much higher than point mutations. The infrequent point mutations could assist in determining kinship between individuals. The set of mutations found in an individual was a true representative of the total population mutation frequency. We demonstrate that the mtDNA heteroplasmy of an individual can give us a look into the evolution of sea turtles.

MIXED STOCK COMPOSITION OF STRANDED LOGGERHEAD TURTLES, *CARETTA CARETTA*, ALONG THE EASTERN MEDITERRANEAN COAST OF TURKEY

Oguz Turkozan[1], Can Yılmaz[1], Sezgin Karaman[1], Askın Hasan Ucar[2], Serap Ergene[2], Carlos Carreras[3], Cemil Aymak[4]

[1]Adnan Menderes University
[2]Mersin University Sea Turtles Application and Research Center, Mersin, Turkey
[3]Departament de Genètica, Microbiologia i Estadi-stica and IRBio, Universitat de Barcelona, Av.Diagonal 643, 08028 Barcelona, Spain
[4]Bulancak Technical and Industrial Vocational High School, Giresun, Turkey

Sea turtles are migratory species and therefore assessing the origin of these animals in foraging areas carries great importance for the conservation and management of these species. In the Mediterranean there are reasonable number of studies carried out but eastern Mediterranean is an important gap despite being identified as foraging ground previously. Adana-Mersin region is an important hot spot for the green turtle nesting in the Mediterraenan. For this study we provided tissues from 135 loggerhead sea turtles stranded on the nesting beaches and coasts between Adana and Mersin Provinces of Turkey between the years 2009 and 2012. Tissue samples were preserved in 96% ethanol until DNA extraction. A fragment of 862 base-pair (bp) of the mtDNA d-loop region was amplified by polymerase chain reaction (PCR Mastercycler Personel, Eppendorf, Germany) using the primer pair LCM15382 (5'- GCT TAA CCC TAA AGC ATT GG -3') and H950 (5'- GTC TCG GAT TTA GGG GTT TG -3') (Abreu-Grobois et al., 2006). BAYES software (Pella and Masuda 2001) with MMC (Markov-Chain Monte Carlo) method was used to carry out mixed stock analysis (MSA). This analysis estimates the proportion of individuals in the stock coming from different rookeries. A total of 5 haplotypes were identified in 135 stranded turtles. Of these haplotypes one was novel (CCA2.14) and CCA44.1 was previously recorded from Atlantic but reported for the first time in the Mediterranean. The remaining haplotypes (CCA2.1, CCA3.1 and CCA53.1) have been previously recorded from the Mediterranean (Carreras et al., 2007; Garafalo et al., 2009; Yılmaz et al., 2011). The most frequent haplotypes were CCA2.1 (83.7%) and CCA3.1 (14.1%). The haplotype and nucleotide diversity were 0.281 and 0.00035 respectively. The results of mixed stock analysis showed that almost all turtles come from Turkey, specifically from west (TKW) (29%) and east (TKE) (32%) with smaller contribution from Lebanon (17%).

HAS OVEREXPLOITATION OF THE CARIBBEAN GREEN TURTLE CURTAILED THE MAXIMUM ADULT SIZE OF THE TORTUGUERO GREEN TURTLE COLONY?

Roldán A. Valverde[1], Emma Harrison[1]

[1]Sea Turtle Conservancy

Overexploitation is an anthropogenic phenomenon that impacts wildlife populations. Today, about one third of vertebrates are endangered due to overexploitation. Green sea turtles in the Caribbean have been hunted aggressively since the arrival of the Europeans to the New World. It is recognized that this has caused significant population reductions in the Caribbean, with some historically known rookeries having been exploited to extirpation. Many populations subjected to overexploitation exhibit a significant decrease in maximal adult size as animals are not allowed to achieve their full growth potential before being hunted. We hypothesized that historical exploitation of Green turtles in the Caribbean curtailed maximum adult size

in the Tortuguero population. To address this hypothesis, we analyzed data on maximal Straight Carapace Length (SCL) for the Tortuguero population for the period 1955-2015. Population trend analysis shows that the Tortuguero population has been increasing significantly since the early 1970s. A prediction is that perhaps the number of smaller females is elevated during the period of growth of this population. The Sea Turtle Conservancy database contains a total of 39,584 records since the project was initiated by Dr. Archie Carr. A decadal-based analysis (1955-1964; 1965-1974; 1975-1984; 1985-1994; 1995-2004; 2005-2015) showed that there has been virtually no change in the mean decadal SCL, with the overall mean being 99.20 ± 0.02 cm. It is possible that the impact on maximal attainable adult size had already occurred in this population before the project began in 1955. This short study exemplifies the importance and significance of long-term records collected systematically on a reference sea turtle population of basin-wide importance.

ORIGIN OF LEATHERBACKS (*DERMOCHELYS CORIACEA*) FOUND AT FEEDING GROUNDS OFF THE URUGUAYAN COAST

Gabriela M. Vélez-Rubio[1,2], Milagros López-Mendilaharsu[1], Maria Noel Caraccio[1], Alejandro Fallabrino[1], Laura Prosdocimi[1], Erin LaCasella[3], Peter H. Dutton[3]

[1]Karumbé, Av. Rivera 3245, C.P.11600 Montevideo, Uruguay
[2]Marine Zoology Unit, Cavanilles Institute of Biodiversity and Evolutionary Biology, University of Valencia, Aptdo. 22085, Spain
[3]NOAA Southwest Fisheries Science Center, USA

The leatherback turtle, *Dermochelys coriacea*, like other species of marine turtles, undertakes long-distance migrations between tropical/subtropical nesting beaches and distant temperate foraging areas. Globally, leatherback status according to IUCN is listed as Vulnerable, but the Southwest Atlantic subpopulation is classified as Critically Endangered. The NGO Karumbe has investigated the biology and habitat use of this species in waters off Uruguay for the past 16 years. Satellite telemetry studies have demonstrated that the coastal waters off South America provide important feeding grounds for large juveniles and adult leatherbacks in the western South Atlantic, and "hotspots" have been identified off Rio de la Plata estuary (Uruguay-Argentina feeding grounds). In the present work we analyzed mitochondrial DNA (mtDNA) variation of leatherbacks sampled at Uruguayan feeding areas in order to determine their nesting beach origin. We estimated the genetic composition of the leatherback foraging aggregation based on analysis of 763 bp sequences of the mtDNA control region in order to determine the nesting origin of these animals. We sequenced a total of 29 samples (8 females, 3 males and 18 indeterminate) collected from large juveniles and adult size leatherbacks (mean 137.4 cm; 118.0 – 154.0 cm curved carapace length) incidentally captured in fisheries (34.5%) or encountered stranded (65.5%). We identified 5 haplotypes, the most common (n=19) being Dc 1.1, followed by Dc 1.3 (n=5), DC 3.1 (n=2), Dc13.1 (n=2) and Dc9.1 (n=1). We conducted Bayesian Mixed Stock Analysis (MSA) using data from Dutton et al. (2013) for the key potential source rookery stocks in the Atlantic. Results of the MSA estimates show that the leatherbacks foraging off Uruguay come primarily from the West African rookeries, mainly Gabon and Ghana rookeries (median= 71%; mean =69%, 29% Standard Deviation). Our results are consistent with those obtained in Argentina, with which we share leatherback foraging grounds in the Rio de la Plata estuary. Taken together these findings reinforce our understanding of the connectivity between these breeding and foraging areas on opposite sides of the ocean in the South Atlantic. These genetic results provide new information to link nesting and foraging areas in the South Atlantic. This effort to determine regional stock boundaries and migratory routes is necessary to develop and implement effective conservation measures to mitigate threats both on the nesting beaches and at developmental and foraging areas.

WHY HAS THE KEMP'S RIDLEY DEVIATED FROM AN EXPONENTIAL RECOVERY RATE? A REVIEW OF HYPOTHESES*

Thane Wibbels[1], Elizabeth Bevan[1], Benny Galloway[2], Blanca Zapata Najera[3], Laura Sarti Martinez[4], Francisco Illescas[5], Jaime Pena[6], Patrick Burchfield[6]

[1]Department of Biology, University of Alabama at Birmingham
[2]LGL Ecological Research Associates
[3]Comision Nacional de Areas Naturales Protegidas, Ciudad Victoria, Tamaulipas | Mexico
[4]Comision Nacional de Areas Naturales Protegidas, Ciudad de Mexico, Mexico
[5]Conservacion de Espacios Naturales y Sociedad Civil, Tamaulipas, Mexico
[6]Gladys Porter Zoo, Brownsville, TX, USA

The Kemp's ridley sea turtle was historically the most endangered sea turtle in the world and was near extinction by the mid1980s. Due to intense conservation efforts by Mexican and U.S. Governments, this species gradually began to recover, eventually reaching an exponential recovery rate during the 1990's through 2009. However, the number of nests significantly decreased during 2010, and since that time, the level of nesting has not regained its exponential recovery. The purpose of this presentation is to discuss several of the hypotheses that could potentially account for, or contribute to, the change in the recovery trajectory. As an example, it has been hypothesized that the Deepwater Horizon oil spill significantly impacted various life history stages in the Kemp's ridley population. After such an impact, a temporal lag would be expected before regaining the exponential recovery rate. Additionally, there may have been increased mortality of Kemp's ridleys due to several other factors in the Gulf of Mexico. As examples, there have been several cold stunning events in recent years. Further, since 2009, there has been a significant increase in the recorded number of stranded Kemp's ridleys in the northern Gulf of Mexico. Finally, the recent trends in nesting may also reflect natural fluctuations in the population and/or the population reaching a carrying capacity in the Gulf of Mexico. However, predicted historic levels of Kemp's ridley nesting suggest a much larger carrying capacity back in 1947. Ongoing studies are currently addressing various aspects of these hypotheses.

POPULATION STATUS OF NESTING LEATHERBACK, OLIVE RIDLEY, AND GREEN SEA TURTLES IN PARQUE NACIONAL MARINO LAS BAULAS ON THE PACIFIC COAST OF COSTA RICA

Adam M. Yaney-Keller[1], Nathan J. Robinson[1,2], Jenell Black[1,2], Pilar Santidrián-Tomillo[2,3], James R. Spotila[2,4], Frank V. Paladino[1,2]

[1]Department of Biology, Indiana University-Purdue University Fort Wayne, Fort Wayne, Indiana, 46805, USA
[2]The Leatherback Trust, Goldring-Gung Marine Biology Station, Playa Grande, Guanacaste, Costa Rica
[3]Population Ecology Group Institut Mediterrani d' Estudis Avancats, IMEDEA (CSIC-UIB), Miquel Marques 21, 07190, Esporles, Mallorca, Spain
[4]Department of Biology, Drexel University, Philadelphia, Pennsylvania, 19104, USA

Parque Nacional Marino Las Baulas, located on the Pacific coast of Costa Rica, is a critical nesting site for three sea turtle species: the leatherback, olive ridley, and green turtles. Using a combination of PIT and metal tags, we have been monitoring the population status of leatherback turtles at this site since 1988 and

olive ridley and Pacific green turtles since 2010. Over this period, the number of nesting leatherback populations have decreased by almost 98%, from 1,500 nesting females per year in 1988 to between 20 – 30 females per year the last 3 seasons. Although low, this remains the largest nesting beach for nesting leatherback populations in the East Pacific. In addition, while leatherback continue to decline, olive ridley, and Pacific green turtle nesting populations remain stable, with between 40 – 100 olive ridley and 5 – 20 Pacific green females nesting per year. It should be noted that olive ridley and green turtles may not have been monitored for long enough to identify current population trends and these numbers do not represent historic changes on a decadal scale, yet still these contrasts may reflect the very different threats faced by each species. We recommend that further research is needed to ascertain how threats differ between these species in order to determine appropriate conservation efforts.

BASELINE STUDIES ON THE CONSERVATION BIOLOGY OF GREEN SEA TURTLES (*CHELONIA MYDAS*) IN THE SOUTH CHINA SEA

Frederick Yeh[1,2], Haitao Shi[1], Ting Zhang[1,2], Kaixing Guo[1,2], Lin Liu[1], Morgana de Partee[2]

[1]Hainan Normal University
[2]Sea Turtles 911

The South China Sea, which spans into the Coral Triangle, is one of the richest marine ecosystems in the world, recognized as the global center of marine biodiversity. Nevertheless, this prolific region is one of the least studied areas for conservation due to political and territorial disputes. Through partnerships with local governments and communities, we have been able to collect baseline data for marine turtle conservation biology in accordance with international standards and protocols. From 2012 to 2015, we monitored population genetics, identifying 10 haplotypes through mixed stock analysis, in which 46% consisted of the rare CMP19 haplotype. In 2016, we discovered nesting beaches in the Paracel Islands; the annual survey conducted revealed 151 nests laid 13.57 m ± 5.17 (SD) from the high tide line. From 2012 to 2014, we attached Inconel 681 flipper and PIT tags to 113 sea turtles prior to release from Hainan Island to identify potential foraging grounds and migratory corridors in the South China Sea; 8 were reported caught by fishermen, which elucidated their post-release movements and a high degree of fisheries by-catch threat in the region. Additionally, 10 sea turtles were tracked with ARGOS satellite telemetry; 4 of these turtles remained around Hainan Island, while 6 travelled away to foraging grounds in the Paracel Islands, Palawan Island of the Philippines, Riau Island of Indonesia, and along the coastline of Vietnam. From 2015 to 2016, 224 green turtle blood samples were collected to establish reference intervals for plasma biochemical values. During blood analysis, we also determined reproductive hormone values to correlate with gender and seasonal changes in captivity. To validate sex of immature turtles, we directly visualized the gonads by safely conducting laparoscopic surgery for the first time in China. Laparoscopy and hormone analysis confirmed a preliminary 3.8 female to 1 male gender ratio, consistent with global research results that climate change is producing a female biased sex ratio, potentially escalating marine turtle extinction in the South China Sea.

Social, Economic and Cultural Studies

CONSERVATION CONFLICTS RELATED TO MARINE TURTLE INITIATIVES: CARIBBEAN STUDY CASES*

Hector Barrios-Garrido[1,2], Alfonso Ruiz-Moreno[1], Omar Ramirez-Flores[1], Natalie Wildermann[1,2], Amy Diedrich[1,2], Mark Hamann[1,2]

[1]*James Cook University (JCU)*
[2]*TropWATER*

Conservation conflicts are considered as circumstances that impact nature, when one or more groups of people clash due to their different point of views over conservation objectives. These conflicts usually occur due to the different backgrounds (cultural, social, economic, among others), as well as the previous experiences of involved stakeholders. Often, these conflicts are inevitable. However, some authors affirm that these conflicts can have a positive effect on further changes. The latter is the main reason to improve our understanding about how, where, and when these conflicts have been impacting in conservation initiatives. In developing regions, such as the Caribbean Basin, the socio-economic realities vary among countries and territories. As a result, the conservation conflicts may also differ. These conflicts have been understudied due to the constraints that involve their assessment. In countries where the poverty level is critical, the use of natural resources is almost vital for the survival of their inhabitants. For this reason, the aim of this project was to assess the conservation-conflicts regarding marine turtleâ€™s protection initiatives among different countries in the Caribbean basin. We invited people involved in marine turtle conservation initiatives by email to answer our electronic social survey between September and November-2016 (using both English and Spanish versions). The survey ensured anonymity and included closed and open-ended, linker scale, and categorisation questions. We then compiled, categorised and evaluated the answers. There were 63 fully-responded surveys, with a response rate of 46.6%. The primary outcome was a categorised and scaled list of conservation conflicts that have occurred in the last ten years within marine turtle projects in the Caribbean Basin. The interviewees (n= 63) represented: 41.1% national and international NGOs; 32.7% universities; 20.3% Government agencies, 5.9% others; and they categorised themselves as researchers, project leaders, decision-makers, and volunteers. Our results indicated that lack of enforcement, consumptive and non-consumptive use occurring in the same community, limited funding for protection, and the illegal use of marine turtles were the most frequent conflicts described (in that strict order) by interviewees. All the conflicts proposed in the survey were selected at least once; however, illegal activities occurring in the region also were considered by our respondents, with especial prevalence in the continental Caribbean. These irregular activities varied among the presence of drug smugglers in the area, illegal paramilitary presence, and traffic of marine turtles (products and sub-products). People-people negative interactions were tangible across all the region. Although, the conflicts impacts varied among projects and countries, in some cases they over scaled to physical violence. Previous authors affirm that when the circumstances of a conflict reach physical violence, the solutions are harder (and sometimes impossible) to be achieved. The respondents provided potential solutions to these conflicts, with the majority of them highlighting the key role of governments to achieve these solutions. We encourage national workshops to be organised with multiple stakeholders to tackle some of these conflicts. Our results will be fully available for these and other purposes.

HOW LOCAL ECOLOGICAL KNOWLEDGE CAN GUIDE CONSERVATION INITIATIVES FOR OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS OLIVACEA*) IN COSTA RICA*

Anna Hall[1], Annie Clift[1], Madeleine Beange[1]

[1]Turtle Trax SA, San Francisco de Coyote, Guanacaste, Costa Rica

Social science plays an important role in shedding light on complex conservation issues using traditional ecological knowledge to aid in conservation. Particularly, traditional ecological knowledge helps to create long lasting conservation strategies through describing knowledge regarding the sustainability of local resources. The community of Playa Bejuco, Guanacaste, Costa Rica is one such community who, in partnership with CREMA and Turtle-Trax, works closely with biologists to implement a monitoring program for nesting olive ridley sea turtles (*Lepidochelys olivacea*). Primarily a fishing community, the leaders of the community noted the various anthropogenic impacts affecting the population of nesting sea turtles on Playa Bejuco. This research project examines the way in which cultural beliefs, values, practices and norms guide locals to participate in conservation science initiatives by participating in authentic research experiences. Authentic research experiences consist of local nightly patrols and hands-on experience collecting biometric data of the nesting female turtle, tagging her, and collecting the eggs. Through a series of open-ended interviews and direct observation of participant behaviours, this study demonstrates how knowledge domains around the population of olive ridley sea turtles and ecosystem biology shapes the way locals view and contribute to conservation work. As a result of these interviews over the course of three months, my research shows how the sociocultural value of biodiversity can lay the foundation to a successful practice of conservation and sustainability, framed by how the community speaks to and values the presence of turtles on their beach.

SOUTHERN CALIFORNIA'S SEA TURTLES: PUBLIC PERCEPTIONS AND CONSERVATION IMPACTS*

Sabrina Mashburn[1]

[1]UCSD Scripps Institution of Oceanography Center for Marine Biodiversity and Conservation

East Pacific green turtles reside in southern California year-round. They are part of the threatened Eastern Pacific Distinct Population Segment (DPS), which is ecologically and evolutionarily significant, and has unique adaptations to life in temperate waters of the eastern Pacific. One of the most remarkable features of southern California sea turtles is that they continue to inhabit waters in close proximity to large metropolitan areas, such San Diego, CA and Long Beach, CA., often adjacent to highly industrialized coastal areas. Green turtles in this area are subjected to numerous anthropogenic impacts (e.g. boat strikes, entanglement in marine debris), yet there are currently no programs in place to gauge public knowledge about sea turtles or their willingness to change social norms and practices to alleviate these impacts. This study aims to quantify public awareness and knowledge of sea turtles in Southern California. First, oral surveys were conducted at marinas and waterfront businesses. Then, responses were coded and used to measure general knowledge of sea turtles at each site, as well as respondents' willingness to modify their behavior due to the presence of sea turtles at each site. Preliminary data analysis shows that while 43% of commercial boaters surveyed have encountered sea turtles in the wild, none of them could identify the leading causes of local sea turtle mortality. Most of the recreational boaters surveyed did not know that sea turtles live in southern California. Those that did know about them had seen sea turtles while they were on

the water, and none of them knew that they could report their sightings to NOAA. Responses to the survey are currently being used to inform a public awareness campaign, which includes a tri-fold brochure, website and outdoor signage. The campaign aims to reduce sea turtle mortality through increasing public awareness of southern California sea turtles, as well as knowledge of appropriate measures to take when encountering a sea turtle in the wild. As of November 2016, the Unified Port of San Diego has pledged to support the installation and maintenance of sea turtle habitats signs at all boat launch points in San Diego County, and distribution of educational brochures to all waterfront business owners. The US Fish & Wildlife Service has already begun to distribute the educational brochures to boaters who exceed speed limits within USFWS jurisdiction. More avenues for increasing public knowledge of local sea turtle populations, including radio and television broadcasts, will be explored in the next phase of the project.

CULTURAL SIGNIFICANCE OF THE SEA TURTLE (*CHELONIA MYDAS, ERETMOCHELYS IMBRICATA*) AND THE CHAMORRO PEOPLE OF GUAM

Joshua J. Salas[1], Jessica DeBlieck[1], MaryLou Staman[1]

[1]*University of Guam*

Historically, Chamorro people have relied heavily on the ocean's resources and marine life, including sea turtles (*Chelonia mydas, Eretmochelys imbricata*). From the birth of a child to becoming a revered ancestor, the Chamorro culture has resonated throughout history with the importance of sea turtles. When the Endangered Species Act was passed in 1978, sea turtles were granted full protection from the local government prohibiting Guamanians from harvesting them for their common cultural uses. This heavy restriction created a significant impact on cultural practices that commonly used the sea turtle as a delicacy, for tool making, or for jewelry. The drastic change in the cultural usage with the sea turtle was not easily accepted by all local Chamorros. Some locals today still illegally harvest the sea turtles. Those who have experienced cultural practices involving sea turtles, before the Endangered Species Act, do remember the sea turtle as a prized resource that was used for special occasions. Annual ceremonial village fiestas and weddings are commonly celebrated occasions. Historically sea turtles were prepared in a special dish to celebrate such special occasions when available, but today a roast pig, lobsters, eels, and sting rays are often prepared as special dishes as an alternative. Cultural jewelry and tools were also created with the sea turtle's shell. They represented wealth and when Chamorro's were organized under a caste system, only high-ranking people were allowed to possess them. Today, jewelry is now commonly made with shells and is sometimes molded into symbolic items to represent our culture. Traditional tools were also modernized with steel and didn't require the usage of the turtle shell, thus mitigating the harvesting of the sea turtles in this case. Regardless of the restrictions and cultural adaptation from sea turtles, sea turtle endangerment is recognized to a significant extent leading to greater cooperation and greater measures of preservation and restoration. Local communities have been involved in the management, preservation, and protection of the sea turtles. Their contributions vary from nesting habitat clean ups, reporting of washed-up sea turtles, reporting of nests found in certain areas, reporting of illegal harvesting or possession of a sea turtle, and general awareness. A local turtle watching community has also been formed and is active in locating and reporting turtles or their nests around Guam. Management practices on Guam restrict any physical interaction with sea turtles and their nests according to local and federal law thus restricting any use of a sea turtle for common cultural purposes. While sea turtles still remain culturally important to Chamorros, increased awareness and management efforts have helped re-shape the role they play and although they are endangered, their presence alone is a representative piece of Chamorro culture that lives on with their survival as a historically treasured species.

CAN ALTERNATIVE LIVELIHOODS SUCH AS ECOTOURISM BE A SOLUTION TO CONFLICT BETWEEN MARINE TURTLE CONSERVATION AND FISHERIES?*

Ridhi Chandarana[1], Kartik Shanker[1,2,3], Muralidharan M[1]

[1]Dakshin Foundation
[2]Ashoka Trust for Research in Ecology and the Environment (ATREE)
[3]Indian Institute of Sciences

In areas where marine turtles and local communities coexist, conflicts emerge due to the space shared on land and the sea. With mounting international pressure to conserve turtles, most decisions to reduce this conflict are made by people without an understanding of the scenario on the ground. Conservation measures fail when opinions and perspectives at the grassroots level are not taken into consideration. At the Rushikulya mass nesting rookery, local fishers face livelihood losses due to conservation measures in place during the turtle breeding season. “Alternative livelihoods” have cropped up as a solution multiple times and failed to deliver. To make decisions and give recommendations for policy for the use of this space without the necessary background exacerbates the conflict and renders any action unsustainable. Our study therefore aimed to understand reasons for failure of past efforts at conservation, the rationale behind the need for alternative livelihoods and in particular, the potential of tourism focused on turtles as an alternative livelihood. A mixed methods approach involving quantitative and qualitative data was employed to understand the situation. Thematic analysis was used to analyse the qualitative data and basic statistics were used for the quantitative data. 134 semi structured interviews were conducted with local community members, wildlife scientists, representatives of NGOs and different government officials composed of members of the forest department, fisheries department, tourism department and district administration. In addition, 13 tourists were given a questionnaire to ascertain their perspective and preferences. Our findings show that some of the opinions held by the community are contrary to popularly held beliefs about conservation and livelihoods. Such studies can inform management decisions and improve the success of conservation when local communities are involved. In order for alternative livelihoods to work, it is necessary to understand the needs of the community and their perspective as well as capacity. This study exhibits the importance of social science in generating understanding that can be critical for conservation and management.

TOURIST PERCEPTION ON COMMERCIAL SEA TURTLE HATCHERIES IN SRI LANKA*

Rupika Subashini Rajakaruna[1]

[1]University of Peradeniya

Sea turtle hatcheries are well established in Sri Lanka and are all operated by private owners. The contribution of turtle hatcheries towards conservation of sea turtles is highly debated, and the Department of Wildlife Conservation (DWC) in Sri Lanka holds the view that management practices of the hatcheries are not conducive to the conservation of sea turtles. The prime motive of the current hatcheries in operation is profit, relying on tourists for their viability. Here we conducted a questionnaire survey to assess the touristsâ€™ perception on turtle hatcheries in Sri Lanka. One of the most visited hatcheries in Bentota in the southwestern coast was selected. After obtaining the verbal consent, a self administered questionnaire was given to both foreign and local tourists visiting the hatchery. Some visitors were interviewed if they were willing to participate. Questions gathered the background information of the visitor, their knowledge

about sea turtle and their perception on the activities of hatcheries and their contribution towards conservation of sea turtles. Information from 126 visitors was collected, of which 91% were foreign tourists, mostly (53%) from the European countries including UK, Germany, Netherlands and Denmark. More females (61%) participated. The education level of the most participants was high having an undergraduate degree or above (77%). Although the majority had a good knowledge about sea turtles, 65% of the respondents were not aware that the turtles were globally protected animals. Level of education or the profession had no effect on their responses (Chi square test; p> 0.05). The majority (93%) didnâ€™t agree that the hatchery was operated mainly for making profits and 85% considered that the hatchery was a good ecotourism venture. Many visitors (70%) believed that more hatcheries should be opened. Only 21% of the visitors interviewed had visited other hatcheries elsewhere, of which 93% said that this hatchery was better or no difference than the other hatcheries they visited. Although some visitors (36%) have said that the there weren't enough space for adults and sub-adults in the rearing tanks, 84% agreed or strongly agreed that the overall condition in the hatchery was good. A majority of the respondents (75%) disagreed to the question whether the hatchery keeps too many adults/sub-adults and/or hatchlings for display. Most of the visitors (81%) were convinced that the hatchery contributes to sea turtle conservation and more than half of them (59%) felt that more hatcheries should be opened but few (4%) disagreed to this idea. The survey shows that the tourists have a positive perception on hatcheries and this coupled with the economic benefits to the community, we highlight the importance of implementing and strict monitoring of the hatchery management guidelines in order to improve the hatchery practices to make a positive contribution towards sea turtle conservation.

Special Theme: Citizen Science

SIREN-TURTLES, A MOBILE APP TO FACILITATE DATA COLLECTION, COMPARABILITY AND SHARING OF BEACH NESTING DATA*

Takoukam Kamla Aristide[1]

[1]*AMMCO*

Marine megafauna including sea turtles provide valuable ecosystem services as most are keystone species whose extirpation in a community would more likely lead to its imbalance. Although most of these flagship species are admired by many, their populations remain threatened by increasing anthropogenic activities. Data on marine megafauna necessary for their protection is scant as compared to their terrestrial homolog; the reason being the complexity and the high cost of data collection, and limited financial resources. The lack of scientific skills, in addition to poverty in developing African countries, make data collection even more challenging, while hunting pressures remain concerning. The African Marine Mammal Conservation Organization (AMMCO), created the first mobile application, SIREN, dedicated to marine mega-fauna in West Africa in 2015 and sponsored by PPI-IUCN. The application aims to provide cost-effective, and participative opportunistic data collection to reduce data gaps on marines species in Africa. The App enables people to collect and record minimum data (date, time, GPS location, species, and photo) of marine animal opportunistic sightings. More than one hundred sightings were reported by fishermen successfully to our database during this pilot phase. More than 20% of the reported sightings were dead or by-caught sea turtles. This success inspired AMMCO to use a similar mobile solution to address some issues related to beach nesting monitoring data, which are not used to their optimum potential. Some of the issues include the incompatibility of data formats that does not allow the comparability across geographical areas, limited skills to analyze the data and the difficulty of digitizing the data and centralizing them to a larger database. AMMCO, in collaboration with RASTOMA, is developing SIREN-Turtles, a new version of the SIREN App to be used around the world by sea turtle researchers for an easy and systematic collection of nesting beach monitoring, including data. The App could be used offline and will be available on iOS, Android and Web interface in French and English, for a start. Each uploaded data will be accessible in an interconvertible format on the AMMCO website with the concern of the data contributor. Because data collected through SIREN-Turtle will match the SWOT minimum standard for nesting data, it will be readily connectible to feed the SWOT database or another database at the local, national, or global levels in only a few clicks. Using the Girondot model integrated into our server, the user could process their data online, generate and export statistics and graphs of interest in just a few clicks. Therefore, SIREN-Turtle will allow for easy data collection, secured storage, quick data processing, fast and easy data sharing and enhance comparability across geographical areas and projects. Overall, while SIREN will allow general users to contribute with opportunistic dead, live, or nesting data to inform on threats and hotspots, SIREN-Turtles will be dedicated to sea turtle researchers to boost the accessibility and usability of beach nesting data. Both will better support decision making to improve the protection status of sea turtles locally, nationally, and globally.

THE DEVELOPMENT OF LOCAL AND GLOBAL CITIZEN-SCIENCE SEA TURTLE MONITORING*

Dustin S. Baumbach[1,2], Edward Anger[3], Stephen G. Dunbar[1,2,4]

[1]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc.), Loma Linda, CA 92350
[2]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA 92350
[3]ScubaTed, Roatán, Honduras
[4]Protective Turtle Ecology Center for Training, Outreach, and Research Inc. (ProTECTOR Inc. – Honduras), Tegucigalpa, Honduras

Geographic Information Systems (GIS) are changing how ecosystems and individual species are monitored by providing ease of access to wide-scale spatial views. With recent developments in web-based GIS, citizen-scientists are now able to participate with researchers in scientific studies by providing data points of their own observations. Recently, we developed and launched two interactive maps with nine editable fields for logging in-water turtle sightings around the islands of Roatán and Utila, located in the Bay Islands of Honduras. Ninety-eight dive site locations for the island of Roatán and 74 dive site locations for the island of Utila were mapped with lat/long positions on Esri's ArcGIS Online web map. We embedded these maps on the website for the Protective Turtle Ecology Center for Training, Outreach, and Research, Inc. (ProTECTOR, Inc.) and distributed it to dive shops on Roatán for use in logging turtle in-water sightings, and uploading photographs and metadata. Dive shops on Utila have not yet been provided with the sightings link because we have not returned to that island since the maps were launched. To date, 105 sea turtle sightings have been logged for the Roatán map. However, we recognized that dive tourists do not always have immediate access to a computer to log sea turtle sightings. In order to facilitate the collection of important information, smartphone applications designed to map wildlife sightings are used for citizen-scientists to aid researchers in collecting scientific data. Many smartphone applications are currently available for Androids and iPhones that help log animal information worldwide utilizing GPS positions from the user's phone. We recently designed a smartphone application called Turtles Uniting Researchers and Tourists (TURT) for logging global citizen-science sea turtle sightings. We utilized Esri's AppStudio native quick report template to specify the basic identifying application information, insert the feature class, and create custom code to provide instructions for logging information. The feature class was then linked to our interactive web map in order to facilitate the ease of logging sightings on Roatán without having to use a computer. We limited identifying information provided to the user to prevent poachers from taking advantage of GPS locations for turtle sightings. After TURT was released to the Google Play and Apple App stores, we announced the release of the application to the C-Turtle e-mail list and to dive shops in the Caribbean and southeast Asia. Currently, 146 separate turtle sightings consisting of 39 Greens, two Leatherbacks, 102 Hawksbills, two Loggerheads and one undetermined turtle have been logged for the United Kingdom, U.S. Virgin Islands, Honduras, Guam, and in the United States, Florida, Hawaii, and Texas. We suggest that dive guests should be engaged directly to inspire self-motivation to act as citizen-scientists. However, we have found it challenging to engage the public and other researchers to use these applications, and are currently considering the use of incentives. These data may allow marine protected area managers to easily estimate and monitor sea turtle populations with the combined use of TURT and region-specific web maps.

OPPORTUNISTIC LEATHERBACK SIGHTINGS OFF SOUTHERN NEW ENGLAND: SPATIAL AND TEMPORAL OCCURRENCE RELATIVE TO SATELLITE-DERIVED SEA SURFACE TEMPERATURE, CHLOROPHYLL A AND BATHYMETRY

Karen Moore Dourdeville[1], Robert Prescott[1], Kara L. Dodge[2]

[1]Mass Audubon Wellfleet Bay Wildlife Sanctuary, Wellfleet, MA, USA
[2]Woods Hole Oceanographic Institution, Woods Hole, MA, USA

Mass Audubon Wellfleet Bay Wildlife Sanctuary has actively solicited boaters to watch for and report sightings of sea turtles off southern New England since 2002, through a website, seaturtlesightings.org, a phone hotline, and various forms of advertising and outreach. Four species of sea turtles occur in these waters, subadult and adult leatherbacks (*Dermochelys coriacea*), juvenile Kemp's ridleys (*Lepidochelys kempii*), juvenile greens (*Chelonia mydas*), and juvenile and subadult loggerheads (*Caretta caretta*). These waters are one of the most highly boat-trafficked regions off the US coast, both by recreational and commercial vessels. Boat strikes and entanglements in fishing gear are threats to all four species, but we see evidence of these hazards mostly in leatherbacks. We present spatial and temporal leatherback sightings, plotted in relation to satellite-derived sea surface temperature, chlorophyll a and bathymetry. While opportunistic sightings are skewed toward areas frequented by boaters and cannot be corrected for effort, it is still instructive to look for patterns in leatherback distribution relative to oceanographic variables within these heavily trafficked areas. We also discuss the educational outreach to boaters, which is designed to teach search image, i.e. what a leatherback might look like to an approaching boater, and to increase awareness of the presence of sea turtles.

THE FISHERS KNOW: USING LOCAL EXPERIENCE TO COLLECT DATA ON A POORLY KNOWN SEA TURTLE POPULATION*

Noemi Duran[1,2], Marsha K. Wright[1,2], Lidia Salinas[1,3], Stephen G. Dunbar[1,2,3]

[1]Protective Turtle Ecology Center for Training, Outreach and Research Inc. (ProTECTOR Inc.), Loma Linda, CA
[2]Marine Research Group, Department of Earth and Biological Sciences, Loma Linda University, Loma Linda, CA
[3]Protective Turtle Ecology Center for Training, Outreach, and Research - Honduras (ProTECTOR - Honduras), Tegucigalpa, Honduras

When working on sea turtle conservation projects, support and cooperation of local communities are always desirable, as they constitute valuable assets for success in the long run. During the summers of 2015 and 2016, researchers from Loma Linda University and ProTECTOR Inc. carried out a program to involve local artisanal fishers from the South Coast of Honduras in collecting data on the juvenile hawksbill (*Eretmochelys imbricata*) sea turtles that inhabit Honduran waters within the Gulf of Fonseca. Although there were several anecdotal reports of hawksbills along the southern coast of Honduras, few scientific data have been reported for this population. In June, 2015 we contacted several fishers in the area of San Lorenzo, which confirmed that during the summer months they often capture small and medium-sized hawksbill turtles as by-catch when fishing close to the estuaries. We offered fishers the opportunity to collaborate in a conservation project by collecting some basic data (Curved Carapace Length, Curve Carapace Width, and photos) from entangled hawksbills caught while fishing, before releasing them. Some

fishers agreed, and data from seven juvenile hawksbills was collected in 2015. In 2016 we continued the project and conducted a formal training for fishers, through a four hour workshop held on July 19th. Ten fishers participated in the workshop, which covered general information on sea turtles (species, life cycle, threats), identification of the species present in the Gulf of Fonseca (olive ridley, green, and hawksbill), and a practical session on sea turtle management and data collection. Using a stuffed toy of a sea turtle we trained them on how to handle, measure, and photograph the animals. We also covered how to record GPS positions of capture locations, although most fishers did not have smart phones with GPS technology. We agreed to provide fishers a small economic incentive for their collaboration, compensating them for the time they missed from fishing while recording data from turtles, and they agreed to provide a video of the release of each animal. Eleven animals were reported in 2016, ten of which were juveniles, and the other an adult female. The average CCL of juveniles from both years was 43.9 cm. The reported female, with a CCL of 68.9 cm, had tags in the two front flippers. We found that she had been tagged by Fauna & Flora International in June, 2016, while nesting in Estero Padre Ramos, Nicaragua. These data suggest that females nesting outside the Gulf of Fonseca may be residing or foraging within the Gulf in Honduran territory. Although we only have four GPS locations for turtles captured by fishers, they are all located in small channels in the estuaries. Thus, it is likely that turtles are swimming into these channels looking for food or resting sites. We plan to keep working with the fishers in the area for the following seasons. Besides the valuable data obtained at very low cost, these types of projects motivate local communities to become involved with turtle conservation efforts and thus, should be supported and promoted.

PHOTO IDENTIFICATION OF GREEN SEA TURTLES IN LONG BEACH, CALIFORNIA

Saki Hashimoto[1], Parth Jhaveri[2], Hugh Ryono[2], Pam Ryono[3]

[1]Miami University, California Polytechnic University, Pomona, CA, USA
[2]Aquarium of the Pacific, Long Beach, CA, USA
[3]NMFS West Coast Region, Long Beach, CA, USA

Since 2008, an observational study and directed research of green sea turtles (*Chelonia mydas*) in the San Gabriel River in Long Beach, California, have confirmed that this area hosts a persistent year-round foraging aggregation of green sea turtles, which are considered threatened under the Endangered Species Act. Although much has been learned about green turtles and their use of this area, many fundamental questions remain about the number of green turtles that may be present, as well as patterns of immigration, emigration, and residence in the San Gabriel River. While directed tag-recapture research is well underway, there appears to be an opportunity to greatly enhance those efforts through photo identification studies. The development of photo identification techniques as a valid means of studying some sea turtle species has accelerated in recent years, although most progress has been reported from projects where individuals have been captured or stranded, or documented at close range in the water by underwater cameras. Here, we report on the development of a photo identification study using photographs of free-swimming green sea turtles surfacing in the San Gabriel River taken by citizen volunteers. The lower San Gabriel River offers easy public access to a relatively confined river channel where the opportunity for observation and potential photography of surfacing green turtles is much greater than in more open water settings. After exploring a number of program options available, we decided to use the computer software Interactive Individual Identification System (I³S) previously used in other studies, and developed our own framework for evaluating photos for matching. Based on our initial analysis, we were able to clearly identify 77 individual right and left head profiles, with 16 of those profiles observed on more than one occasion in the San Gabriel River between the years 2006 and 2015. Interestingly, the right side was the dominant profile clearly distinguished from usable photos (60 out of 77 profiles), suggesting that the minimum number of individuals documented in the San Gabriel River during this time period was 60, and that at least 15

individuals were resighted during this time period. Our results clearly illustrate the potential usefulness of photo ID data at this study site. Our next steps involve development of an organized photo collection program that can be incorporated into existing citizen-science monitoring efforts, as well as additional participation from the public anytime photos can be collected. The project is expected to engage the public directly in the scientific process, which is likely to increase public awareness and incentives to promote environmental stewardship and sea turtle conservation locally and beyond.

USING CITIZEN SCIENCE TO MONITOR SEA TURTLE POPULATIONS IN REAL TIME AROUND TWO MALDIVIAN ISLANDS

Jillian Hudgins[1], Chiara Fumagalli[2]

[1]*Olive Ridley Project Plymouth United Kingdom*
[2]*Coco Collection Resorts (former address) Maldives*

Coco Palm Dhuni Kolhu and Coco Bodu Hithi are two resorts islands in the Republic of Maldives run by Coco Collection Resorts. The resorts employ a resident marine biologist who has participated in a Maldives-wide sea turtle photographic ID program since 2013. Every day across the Maldives, thousands of tourists and locals are snorkeling or diving with underwater cameras and encountering wildlife. Our photo-ID program chose to harness this potentially large workforce for data collection as a non-invasive research project to study green and hawksbill population dynamics around these two islands. A photo-ID program requires little training – simply the ability to snorkel or SCUBA dive and take a good photo. The use of tourists and locals as citizen scientists increases the workforce and data coverage immensely. This means that a regular, consistent monitoring program can evolve to create a real-time look at the sea turtle population at a particular reef. New discoveries have emerged from this citizen-science collected data. For example, on Dhuni Kolhu Island, a series of photos of a nesting female allowed for the first calculation of the internesting period for green turtles in the Maldives (15.25±2.66 days). Additionally, a series of photos of a juvenile hawksbill turtle over four years, showed it maturing into an adult male. The photos of this turtle, along with associated measurements of its carapace by the marine biologist, allowed us to estimate size at maturity for this male hawksbill turtle as 60-62 cm SCL. Using citizen scientists as part of a research project will not, necessarily, give us all of the answers, but, it will certainly generate questions for the people involved. It allows for vast education and outreach potential, and certainly more memorable vacations, as the photographers come to know sea turtles as individuals. This increased awareness potential, and the involvement of more Maldivians in the project, means that sea turtles have now become a source of eco-tourism income for the country. The participation of citizen scientists is both a powerful awareness tool and a method of gathering a long-term, consistent data set in remote areas that could otherwise not be surveyed given the time and resource constraints. The key to the success of the program is creating a network of engaged citizen scientists and developing a long-term, personal connection between them and the animals being studied. A citizen science photo ID program can be used to fill gaps in scientific knowledge and increase the economic value of the studied species by expanding awareness and education of local companies and individuals.

TEN YEARS OF CITIZEN SCIENCES AROUND SEA TURTLE PHOTO-IDENTIFICATION: LESSONS LEARNED AND PERSPECTIVES*

Claire Jean[1], Stéphane Ciccione[1]

[1]*Kelonia*

Citizen science offers many benefits for sea turtle research and conservation. It may provide almost continuous data for a broad range of locations as citizens spend often more time in the field than researchers. In the meantime, it may allow increasing public awareness of the conservation status of these endangered species. Cautions should be taken regarding bias linked to untrained contributors or personal interpretation of data before transmission. This bias is automatically reduced by linking photos to data in photo identification programs. The species may be identified as well as the approximate size and sex if they are visible, and the date of sighting is also controlled in the file properties. The only data that remains uncertain is the sighting location. In many applications (areas where sea turtles cannot be caught easily, for foraging population studies, to complement other identification methods…), using a photo-ID method is particularly of interest. The involvement of the diving community appears very helpful, as it allows complementing scientific data. With the development of new applications and computer-assisted programs, this technique offers wide perspectives for individual surveys. A monitoring program on foraging green and hawksbill sea turtles around Reunion started in 2005 along with the development of TORSOOI photo-ID recognition software and the launch of a public information campaign to encourage citizens to contribute by sharing their photos and observations. This program involved a total of 180 local recreational divers who voluntarily sent their photos and videos with data associated. More than 2,800 sightings have been reported to date leading to 549 individual identifications, and 1,597 resightings (268 individuals) for both species. The older sighting report for an individual still monitored today in a foraging ground is approximately 9 years. Data collected throughout this program also shed light on key research issues related to spatial attachment and residency patterns for both species. It constituted a relevant dataset to prepare and supplement Fastloc-GPS individual tracking programs, as it allowed targeting specific spots for individual capture before going on the field and covering a longer period of time. Photo retrieval from personal hard disks enabled correcting multiple identifications after tag loss on 2 of the 4 remaining nesting females in Reunion. Similarly, the monitoring of sea turtles wounds healing over years in their natural environment proved to be very efficient. The citizen science program also demonstrated a real passion in the public who may sponsor turtles and obtain updates on health and other records and location. At the same time, this involvement contributes to marine turtle preservation as a powerful awareness tool. To this end, a website dedicated to divers was developed to allow participants to search turtle ID online after their dive and access general knowledge on sea turtles. As technology quickly evolves, new emerging applications, such as completely automated photo-ID programs, should revolutionize sea turtle identification and monitoring over time. This low-cost method could then be applied in a more systematic manner over large amounts of data and for regional and global scale population monitoring.

APPLICATION OF COMMUNITY BASED SEA TURTLE CONSERVATION STRATEGIES TO CONSERVE ENDANGERED DUGONGS IN SRI LANKA

Thushan Kapurusinghe[1], Tharanga Herath[1], Himali Purnima[1], Shayma Wijekulasuriya[1], Dhanushka Mahanama[1], Lucia Reyna[1], Maya Bankova[2]

[1]Sri Lanka Turtle Conservation Project
[2]MBSCF

The Sri Lanka Turtle Conservation Project (SLTCP) has been working since 1993 to protect endangered marine turtles. In 1996, SLTCP began its pioneering community based in-situ marine turtle nest protection in Rekawa, Southern Sri Lanka by employing the local egg poachers as nest protectors. The project implemented several community incentives programmes, such as batik, sewing, ornamental fish breeding, coir mats and turtle watch tourism, as alternative income generation activities. Community members were mobilized as Community Based Organizations (CBOs) and in 2006, Rekawa beach was officially declared Sri Lanka's first marine turtle Sanctuary. In 2012, SLTCP handed over the Rekawa turtle conservation efforts to the local community members and since then it has become a financially sustainable community driven turtle conservation project. SLTCP used combined approaches in conservation efforts, such as providing alternative livelihoods, creating awareness, law enforcement, policy making, capacity development and building partnerships to achieve the conservation targets. Rekawa project is a success story that could be replicated in other locations in the world. SLTCP used experiences gained from Rekawa to design and implement a new project in the Gulf of Mannar to conserve endangered Dugongs (*Dugong dugon*) and seagrass meadows. Dugongs are a key stone species, supporting the intricate balance of coastal ecosystems, such as seagrass beds and mangrove habitats. Dugongs maintain the health and regeneration of seagrass through cropping. Healthy seagrass also provides vital foraging grounds for Green Turtles (*Chelonia mydas*) in the Gulf of Mannar. The largest dugong population in South Asia is in the Gulf, the waterway between Sri Lanka and India. Dugongs inhabit Sri Lanka's northwest coast, between Kalpitiya and Jaffna, areas abundant in seagrass and mangrove forests. Dugongs that once commonly inhabited Sri Lankan waters facilitated a commercial dugong fishing industry, and for decades, dugongs were hunted for their meat. The meat was popular among the coastal communities, believed to have aphrodisiac properties. In the 1950s, up to 150 dugongs were fished in the Mannar Gulf. Dugong fishing was legal until the Fauna and Flora Protection Amendment in 1970. This legislation could not prevent the continual decline in dugong sightings that followed decades of fishing. Today, dugongs continue to be victims of incidental catch from unsustainable fishing methods and are listed as threatened. The ongoing Dugong and Seagrass Conservation Project (DSCP) was initiated in 2015 with six project partners from Sri Lanka. SLTCP's project activities take place in six villages in Kalpitiya and Puttlam. Community incentive programmes include batik, sewing, crab aquaculture, fish breeding, sea bass culture and salt production. Furthermore, legal fishing nets have been distributed to replace illegal nets. The project also provided toilets, audio-video equipment, and water tanks to schools. In addition, education and awareness programmes are extensively conducted within the target communities. As dugongs and sea turtles share the same habitats in the Gulf of Mannar, it is vital to protect these seagrass habitats to ensure the survival of dugongs and sea turtles as keystone species.

CITIZEN SCIENCE MONITORING OF GREEN SEA TURTLES IN LONG BEACH CA*

Dan Lawson[1], Barbara Ramon[2], Cassandra Davis[2], Kim Thompson[3], Eric Zahn[4]

[1]NMFS West Coast Region, Long Beach, CA, USA
[2]California State University, Dominguez Hills, CA, USA
[3]Aquarium of the Pacific, Long Beach, CA, USA
[4]Tidal Influence, Long Beach, CA, USA

In 2010, the year-round presence of ESA-threatened green sea turtles (*Chelonia mydas*) in the San Gabriel River, located in Long Beach, California, was established through documentation of observations made by professional biologists and local citizens. Representing the northern-most persistent foraging aggregation of green sea turtles known along the west coast of North America, this easily accessible location presents numerous opportunities to better understand green sea turtle ecology in an urbanized setting and to establish long term research and monitoring programs that can be used to track the progress of population recovery and inform local management actions. In addition, this location is well suited to serve as a platform to promote public awareness and involvement in sea turtle conservation activity. In 2012, a group of interested citizens in Long Beach, in partnership with the local NMFS Office, initiated a citizen science monitoring program to record simultaneous observations of sea turtles once a month at selected stations spread throughout a significant stretch of the lower San Gabriel River where green sea turtle sightings are common. To date, forty-seven monthly surveys have been conducted by 339 trained volunteers. The continued year-round persistent presence of green sea turtles recorded during every survey and throughout all portions the study area cements the fact that this area hosts many more individual green turtles than initially realized, and is significant to the green turtle population in California. Here we report on the development of this citizen science program, including ongoing evolutions to address data quality as well as other lessons learned through development of a novel citizen science program. We also report on the data collected from over 4 years of study, as well as comparisons between this data and other relevant scientific data collected on green turtles in this area. Overall, we conclude that this program has significantly increased the local knowledge and interest in conservation of green sea turtles at the community level. We also conclude that the efforts to improve the data quality through improved training, refinements in data collection protocols, increased engagement with the volunteers on the results and scientific significance of the research, along with increased accommodation and retention of volunteers, are working to establish this survey as a scientifically valid and citizen science project with a bright future. The data collected from this survey, in combination with other research initiatives, will serve as a baseline for long term monitoring in terms of overall population presence and activity that can potentially serve as a local index of abundance, as well as a means to detect local changes in behavior and habitat usage patterns over time. Of particular interest will be response to changing conditions associated with the transition away from once-through-cooling by two power plants located in this vicinity, as well as other changes in habitat quality possibly including large scale restoration of the lower San Gabriel River and surrounding wetlands area.

COMMUNITY RANGER PROGRAM IN NICARAGUA: PROTECTING SEA TURTLES, REDUCING POACHING RATES, AND EMPOWERING WOMEN

Mercedes Penalba[1], Jairo Coronado[1]

[1]*Paso Pacifico*

In 2008 the Marine Turtle Program began in the Paso del Istmo Biological Corridor, Nicaragua in response to the need to protect four species of sea turtles nesting on key solitary beaches such as Brasil, Guacalito and nearby beaches where nests are harvested and placed in two nurseries. Prior to this program, the nests on this beach were nearly all destroyed by poachers from neighboring community. Therefore, the NGO Paso Pacifico provided training to thirteen men and women from who have worked to provide continuous monitoring of solitary beaches and to cultivate relationships with poachers in order to reduce nest destruction. Community rangers play an important role that includes round-the-clock patrols, biometric data collection, genetic sampling and exhumation, as well as participation in environmental education program activities in support of leading workshops, accompanying children to the nesting beaches, and leading more than five hundred children and young people from seven communities in the Junior Ranger program. The achievements have been the reduction of egg looting to a loss of only 11%, but beyond the percentage, is the fact that today we see an awareness among the poachers that hawksbill and green eggs are threatened and so they are careful to leave them to the community rangers out of their own conscience. Through this ranger program and with the help of partners, we have managed to protect 1819 nests on our beaches from 2008 to 2016, 533 nests of Lepidochelys olivacea, 31 nests of hawksbill (*Eretmochelys imbricata*), 4 of leatherback (*Dermochelys Coriacea*) and 1251 green (*Chelonia mydas agassizii*). More than 70% of the protected nests have been green turtles, and Brasilon is the most important beach at the national level. There are an average of 52 green turtle nests on this beach each year. These numbers highlight the importance of this ranger program for protecting this species in the Eastern Pacific. These results also indicate the program's importance for the eastern pacific hawksbill turtle, specifically the sub-populations that nest on open beaches (Gaos et al. 2016). The lessons learned through the program is that poachers can shift away from the most destructive extractive activities if they are engaged over time. The rangers have been successful at protecting nests, but more importantly through their long-term role as conservation leaders (eight years), they have helped to transform local attitudes and behaviors. Our program is also one of the few where local women also participate as community rangers and they have been extremely effective at awakening consciousness. It is important to include local women when designing protection programs. While the results of Paso Pacifico community ranger program can be measured quantitatively, the true results are felt locally through emotion and care for sea turtles and their future on the beaches of southwestern Nicaragua.

Special Theme: Climate Change

HOW MANY MALES ARE ENOUGH? FEMINIZATIN OF GREEN SEA TURTLE FORAGING AGGREGATIONS IN THE PACIFIC

Camryn D. Allen[1], Summer L. Martin[2], Jennifer M. Lynch[3], Tammy M. Summers[4], Jessy Hapdei[5], Marc R. Rice[6], Jeffrey A. Seminoff[1], T. Todd Jones[2]

[1]Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, CA 92037
[2]Marine Turtle Biology & Assessment Program, Protected Species Division, NOAA Fisheries, Pacific Islands Fisheries Science Center, Honolulu, HI 96818
[3]Chemical Sciences Division, National Institute of Standards and Technology, 45-045 Kamehameha Hwy, Kaneohe, HI 96744
[4]Rainbow Connection Research, PO Box 10001, PMB 370, Saipan, MP 96950
[5]Department of Lands and Natural Resources, P.O. Box 10007, Lower Base Road, Saipan, MP 96950
[6]Cooperative Sea Turtle Research Project, Hawaii Preparatory Academy, 65-1692 Kohala Mountain Rd, Waimea, HI 96743

Wildlife populations are shaped by their environment and obtaining baseline information on how wildlife responds to environmental conditions is critical to identify physiological or behavioral alterations. However, understanding climate impacts is complicated for marine species such as sea turtles where temperature directly regulates key physiological and behavioral parameters that, in turn, have significant consequences on population demography, habitat utilization, and human impacts. Warming may feminize sea turtle populations because sea turtle sex is determined by environmental conditions during incubation (temperature-dependent sex determination). In addition, increased temperatures may alter patterns of migration, movement, and habitat utilization of foraging sea turtles. Molecular tools can be used to elucidate these climate impacts; for example, hormone analysis can determine demographic sex ratios at foraging grounds. Despite its potential, measuring testosterone (male turtles have distinctively higher plasma testosterone concentrations) to determine sex has been applied at surprisingly few sea turtle foraging locations. We previously validated an ELISA testosterone assay and described female biased sex ratios at three green sea turtle foraging locations in the Pacific [San Diego Bay, CA, USA; Long Beach, CA, USA; Howicks Group of Islands, northern Great Barrier Reef (nGBR), Australia] with a greater bias towards females in the newer recruits to the population (immatures). We analyzed 3 additional foraging areas within the Pacific (Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands) and preliminary results also show a female bias in these foraging grounds. Comparison of the present results to previous studies of sex ratios of immature green turtles at foraging grounds in the Pacific found nearly no bias in the early 1980s in Hawaii (1.0F:0.96M) or female-biased populations in the nGBR from 1987 â€“ 1997 (3.2F:1.0M). Sex ratio data for foraging locations provide important baseline information for investigating the potential effects of climate change and consequential feminization of sea turtle populations. Ultimately, due to the continued trend in female biased sex ratios at sea turtle foraging grounds in the Pacific, examination of operational sex ratios will be necessary to determine how many male turtles are enough to maintain sea turtle population viability.

SEA TURTLE POCKET NESTING ON RISING SEA LEVEL DURING MARINE TRANSGRESSION; PRESENT, PAST, AND FUTURE*

Gale A. Bishop[1], Brian K. Meyer[2], Jaynie L. Gaskin[1], R. Kelly Vance[1], Brian M. Shamblin[3], Campbell J. Nairn[3]

[1]*Georgia Southern University Sea Turtle Program @ St. Catherines Island*
[2]*Georgia State University*
[3]*University of Georgia*

Scientists involved in sea turtle conservation on St. Catherines Island, Georgia, a "Sentinel Island," for barrier islands coasts around the world have documented deterioration of sea turtle nesting habitat during the current sea level rise against the continents in "The Modern Transgression." Deterioration of nesting habitat (declining from 25% to 6.2% in two decades) has resulted from rapid erosion of backbeach nesting habitat at 3.0 to 6.0 m/year and fragmentation of three beaches into seven. The formation of coastal features such as wash-over fans and wash-in fans, produced as sand washes over the berm into back-beach marsh meadows and into back-beach maritime forests, coupled with shoreline erosion have lead to the development of nearly continuous tree "boneyards," scarps, and relict marsh mud exposures along most of the St. Catherine's 20 km of beaches. These phenomena contribute to extremely difficult nesting conditions for loggerhead sea turtles [*Caretta caretta* Linnaeus (1758)] as indicated by a 2:1 non-nesting crawl-way to nesting crawl-way ratio. This habitat decline, tracked by a "Rapid Habitat Survey;" forces relocation of up to 67% of "at risk" or "doomed" nests into nearby areas still being used by nesting sea turtles. Such sites act as nurseries to relocated nests. "The Modern Transgression" and the associated beach erosion is exacerbated by impoundment of sediment in coastal rivers and removal of sediment by dredging at ports to the north, reducing the critical southward flow of sand along the Georgia coast, that disturbs equilibrium for the sand supply, threatening this nesting resource, designated in 2014 as "Critical Habitat for the northwestern Atlantic Loggerhead subpopulation of Loggerhead Sea Turtles." Erosional effects are expected to accelerate as the rise of sea level accelerates, leading to increasing barrier island erosion and deterioration of loggerhead sea turtle nesting habitat on St. Catherines Island. Successful conservation protocols developed on St. Catherines Island may provide a model for future conservation up and down the southeastern coast of the USA, and around the world. The pattern of nesting by loggerhead sea turtles on St. Catherines Island during The Modern Transgression led to the documentation of nesting in small, ephemeral pockets of available, adequate habitat on wash-over fans on low areas, wash-in fans along the Maritime Forest edges, and on grassy meadows behind some beaches; defined as "Pocket Nesting." A pocket nest - is a sea turtle nest deposited in a small, ephemeral "pocket" of suitable habitat developed on an erosional shoreline during Transgression; often presenting as an "obstructed nest." By studying the patterns of nesting responses to The Modern Transgression, we hope to predict the future nesting patterns of sea turtles as sea level continues to rise, and to inform the history of nesting during transgressions over the past 125 million years. Initial conservation response to rising sea level has been an increasing rate of relocation into nearby areas still being successfully used by nesting turtles, i.e. into nurseries. Management experience, particularly in 2016, indicates we need to be poised to respond to explosive depredation and extreme weather events. As habitat continues to deteriorate, relocation of nests into hatcheries may be an important option.

BEACH DYNAMICS, HUMAN USE, AND CLIMATE CHANGE: INTERACTIONS THAT IMPACT SEA TURTLE NESTING BEACHES*

Rachel A. Bladow[1], Tiffany Roberts Briggs[1], Sarah L. Milton[1]

[1]*Florida Atlantic University*

As climate change continues, global temperatures will increase and hurricanes may become more frequent; these events could result in greater beach erosion and/or sand accretion, inundation, and thermal stress for developing sea turtle embryos. The aim of this study was to determine the impacts of climate change on embryonic mortality of both green and loggerhead sea turtles in South Florida. Weekly surveys during the 2016 nesting season monitored changes in beach topography from storms along 10 transects of the 3 km study site in Boca Raton, Florida, and related changes to beach infrastructure. Flood-monitoring pipes were installed along the same transects to monitor the extent of inundation in the nests. To monitor incubation temperatures, HOBO U22 temperature probes were placed in the center of the egg chamber; nest temperatures were recorded every 15 minutes. We then collected unhatched eggs from nests in the study site and determined the stage of embryonic development where mortality occurred; the proportion of embryonic death at each developmental stage indicates how sensitive the sea turtle embryos are to thermal stress or inundation. The weekly beach topography surveys showed that there was greater beach erosion due to storm events when the beach was backed by human development than when the beach was backed by a natural dune. This could result in sea turtle nests becoming more vulnerable to inundation with sea level rise. However, the hatching success for inundated nests was not statistically different from nests that were not inundated, because most nests were likely thermally stressed due to the extreme summer heat. During the 2016 nesting season, temperature data loggers recorded average incubation temperatures at or above the critical temperature of 33°C. Even nests that were inundated multiple times still had average incubation temperatures of 33°C. Incubation temperatures above 33°C have previously been shown to result in greater embryonic mortality. Hatching success in Boca Raton during the 2016 nesting season was 38% and 54% for loggerhead and green sea turtles, respectively. Since 2013, sea turtle hatching success for the same section of beach has steadily decreased from over 80% for both species. Therefore, it is vital that current management strategies are enhanced to better protect sea turtle nesting beaches from human use and climate change.

THE EFFECTS OF CLIMATE CHANGE ON OLIVE RIDLEY NESTING BEACHES IN THE SOUTHERN NICOYA PENINSULA OF GUANACASTE, COSTA RICA*

Annie Clift[1,2], Madeleine Beange[1,2], Randall Arauz[1]

[1]*CREMA, Guanacaste, Costa Rica*
[2]*Turtle Trax, Guanacaste, Costa Rica*

Over the last 50 years, atmospheric temperatures have exponentially risen putting various physiological processes at risk in our natural world. As most reptiles display temperature-dependent sex determination, this directly affects population dynamics in a multitude of species. Sea turtle eggs incubate on sandy beaches, which are generally exposed to the elements and thus vulnerable to climate change. As beach temperatures rise, this not only affects clutch sex ratios but also mortality and success of the eggs. The impacts global warming has on nest incubation and sex ratios have been investigated on greens (*Chelonia mydas*), loggerheads (*Caretta caretta*), hawksbills (*Eretmochelys imbricata*), and leatherbacks

(*Dermochelys Coracea*); however, we still see a lack in reports regarding how these changes affect olive ridleys (*Lepidochelys olivacea*). With a pivotal temperature of ~30°C, where a nest produces a ratio of 1:1 male to female, and a high and low of 32°C and 25°C, respectively, this species has a more flexible temperature range and higher pivotal temperature compared to others. With this type of plasticity olive ridleys have not been of utmost concern regarding climate change until now. To study the impact of global climate change on olive ridley nests, we collected an array of data from three nesting beaches in the Southern Nicoya Peninsula of Guanacaste, Costa Rica spanning over 11 years. Since 2004 we have seen seasonal increases in sand temperatures, recorded at nest depth with HOBO pendant loggers, with a peak change of average temperature among all three beaches occurring between 2013 to 2015 of a whole 3.2±1.2°C. When looking at the changes seen from our southernmost beach from 2004 to 2015 we see a considerable change from an average beach temperature of 31±0.5°C in 2004 to an average of 34.4±1.2°C in 2015. Thus, if we use the 30°C pivotal temperature, we can consider that in the early 2000s these beaches were producing hatchlings of a near 1:1 sex ratio female to male. Not only have these beaches shifted in just 11 years from temperatures that produce an even sex ratio to temperatures that produce a female bias ratio, but also to periods in the nesting season that lead to fatal incubation temperatures. These changes have been due, in short, to variations in the rainy season including duration and amount of rain. We see a strong correlation between average sand temperatures per season and monthly rainfall; 2015 reported significantly lower rainfall and subsequently had average sand temperatures frequently rising above 32°C. Depending on the year, shading or cooling techniques have been implemented to mitigate nest fatality and provide an optimal incubation environment within hatcheries. Such practices have allowed us to further compare the effects of temperature among nests relocated to hatcheries and nests left in-situ along the beaches. This study has primarily looked at olive ridley nests; however, we include data from seven leatherback nests and six green nests. With the conclusion of the 2016 nesting season, this year's data will be included to further our study.

CHOOSE WISELY! DIFFERENCES IN ESTIMATED OLIVE RIDLEY SEX RATIOS BETWEEN METHODS*

Catherine E. Hart[1], César Paúl Ley-Quiñonez[2], Alan A. Zavala-Norzagaray[2], Luis Angel Tello[3], Israel Llamas-Gonzalez[4], Marc Girondot[5], F. Alberto Abreu-Grobois[6]

[1]Centro Universitario de la Costa, Universidad de Guadalajara, Puerto Vallarta, Jalisco, México
[2]Instituto Politécnico Nacional, CIIDIR Unidad Sinaloa, Juan de Dios Bátiz Paredes No. 250, Guasave, Sinaloa, Mexico
[3]Campamento Tortuguero Majahuas, Tomatlan, Jalisco, Mexico
4EcoMayto A.C. Mayto, Cabo Corrientes, Jalisco, Mexico
[5]Laboratoire Écologie, Systématique et Évolution (UMR8079), Faculté des Sciences d\'Orsay. Université Paris-Sud, 91405 Orsay, France
[6]Laboratorio de Genética y Banco de Información sobre Tortugas Marinas (BITMAR) Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, UNAM, Mazatlán, Sinaloa, México.

As several other species of reptiles, sex in sea turtles is determined by incubation temperatures, and this makes them vulnerable to changes in the incubation thermal regime. Changes in the incubation conditions or due to climate changes could alter sea turtle primary sex ratios. Thus, it is essential to gather baseline estimates of these values to understand future deviations from current conditions but also to evaluate unintended effects various incubation methods may have on the thermal profiles. Non-invasive methods exist for estimating sex ratios which allow conservation managers to estimate the proportion of male and female turtles produced within clutches. During three Olive Ridley nesting seasons, we recorded incubation temperature profiles of 152 nests (2012: n = 45, 2013: n = 28 and 2015: n= 79) in four conservation camps

in Nayarit and Jalisco states, on the Pacific coast of Mexico. We analysed the differences in temperature regimes between different incubation techniques (polyethylene boxes, beach hatcheries and raised hatchery) and estimated the sex ratio for each of the 152 nests using three different methods: mean temperature for middle third of the incubation period, incubation duration and Girondot & Kaska's reaction norm analysis. Temperatures ranged from 15°C to 37°C. Results indicate smaller proportions of females in all incubations in boxes (0.2-0.6) independently of the method of estimation of the sexual proportion and the month of the year. The highest proportions of males were estimated for the months of February and October-November for all methods, as expected by the decrease in temperatures. However, we found significant discrepancies in estimates of sex ratio, particularly for the method based on the duration of incubation. We discuss where these methods differ in their estimations, probable reasons for this variance. and provide guidelines for their optimal implementation in sea turtle conservation camps.

TEMPERATURE-LINKED HATCHLING MORTALITY AT AN IMPORTANT MARINE TURTLE NESTING SITE: IMPLICATIONS IN A WARMING WORLD*

Jacques-Olivier Laloë[1], Jacquie Cozens[2], Berta Renom[2], Albert Taxonera[3], Graeme Hays[1]

[1]*Deakin University*
[2]*SOS Tartarugas*
[3]*Project Biodiversity*

Climate change is threatening species whose biology is intimately linked to temperature. For sea turtles, an embryo successfully develops within a relatively narrow thermal range. Here we show the effects of incubation temperatures on the survival of hatching loggerhead turtles (*Caretta caretta*) at a globally important rookery. We recorded sand temperatures and measured hatching successes (the percentage of hatchlings surviving incubation) and emergence successes (the percentage of hatchlings emerging from the nest) on Sal, Cape Verde, during the 2008-2014 nesting seasons. Incubation temperatures were between 27.8-32.5 °C (mean = 29.6 °C, SD = 0.9 °C, n = 893 nests) and hatching successes ranged from 0-100% (median = 86.2%, IQR = 73.2-93.7%, n = 2162 nests) over the study period. Median emergence successes were 84.6% (IQR = 70.0-92.8%, n = 2162 nests). Incorporating data from published research we described the relationship between hatchling mortality and incubation temperature and projected that emergence successes will fall to 50-80% by the year 2100 under different climate change scenarios provided by the Intergovernmental Panel on Climate Change. Building on previous work done at this important turtle rookery, we make the advance of considering the linked effects of warming temperatures on hatchling output and on sex ratios for this species that exhibits temperature-dependent sex determination. Our results show that higher temperatures increase the natural growth rate of the population as more females are produced. As a result, we project that numbers of nests on Sal will increase by approximately 30% throughout the century. However, as incubation temperatures near lethal levels the natural growth rate of the population decreases around the turn of the century, threatening the long-term survival of this turtle population. We project that the number of nests at our field site will decrease throughout the 22nd century and will continue to fall for as long as temperatures continue to increase. In summary, our results inform on the long-term viability of an important sea turtle population. We also reaffirm the notion that to a certain extent, warming temperatures will benefit sea turtle populations by increasing the natural growth rate of the population. However, a projected increase in temperature-linked hatchling mortalities will eventually overrun this benefit and threaten sea turtle populations in the long-term. From a conservation perspective it is therefore important to be aware that while nest numbers in Cape Verde will seemingly increase throughout the century, there is an underlining population feminization and a looming threat brought by increased temperature-linked hatchling mortalities. In the future, additional conservation measures may have to be put in place to safeguard this important sea turtle rookery.

SEA TURTLE CLIMATE VULNERABILITY ASSESSMENT*

Matthew Lettrich[1], Mariana M. P. B. Fuentes[2], Joanne Braun-McNeill[3], Vincent S. Saba[4], Kyle S. Van Houtan[5]

[1]ECS Federal in support of NOAA Fisheries Office of Science and Technology
[2]Florida State University
[3]NOAA Fisheries Southeast Fisheries Science Center
[4]NOAA Fisheries Northeast Fisheries Science Center
[5]Monterey Bay Aquarium

Climate change is expected to influence the distribution and viability of many species in marine and coastal ecosystems. These changes have significant implications for conservation of protected species, which are at high risk due to a variety of stressors. NOAA Fisheries is developing and testing a methodology for assessing the vulnerability of sea turtle and marine mammal species to changes in climate. This will provide decision-makers with information on which species may be most vulnerable and why, which will help guide science and management actions. The methodology provides a rapid but generalized approach that uses empirical data and expert elicitation to assess exposure, sensitivity, and capacity to adapt to climate change. From combined exposure and sensitivity/adaptive capacity scores the methodology produces relative vulnerability scores for each species and population, provides information on what attributes contribute most significantly to the species or population vulnerability, and identifies key information gaps. By jointly evaluating current life history traits, current distributions, and projections of future climate the methodology produces a forward-looking assessment of potential species response in abundance, distribution, and phenology. These coarse, qualitative projections of trends in abundance, distribution, and phenology can assist managers in preparing for future management activities. Here we present the sea turtle life history attributes used to assess climate sensitivity and adaptive capacity and the climate factors used to assess exposure to climate change. We describe current efforts to test the methodology and offer a preliminary insight into the outputs that will be provided to managers to incorporate into decision-making.

THE EFFECTS OF A CHANGING CLIMATE ON EMBRYONIC GROWTH, SEX RATIO, AND NESTING PHENOLOGY: A CASE STUDY WITH LOGGERHEADS IN BRAZIL*

Jonathan Monsinjon[1], Milagros Lopez[2], Paulo H. Lara[2], Alex Santos[1], Maria A. G. dei Marcovaldi[2], Marc Girondot[1], Mariana M. P. B. Fuentes[3]

[1]Laboratoire Écologie, Systématique, Évolution, Université Paris-Sud, AgroParisTech, CNRS, Université Paris Saclay, Orsay, France
[2]Fundação Pró Tamar, Salvador, Bahia, Brazil
[3]Department of Earth, Ocean and Atmospheric Science, Florida State University, North Woodward Avenue, Tallahassee, FL, USA

Sea turtles have several life-history traits (e.g. TSD, migratory, ectotherms) that make them extremely sensitive to environmental changes. Embryonic growth rate, hatchlings sex ratio and hatching success are all dependent on incubation temperature. High temperatures are associated with reduced incubation durations, higher proportion of females and lower hatchlings survival. Further, nesting phenology of adult females has been shown to be related to sea surface temperature. Indeed, nesting season can be either

delayed or earlier depending on the temperature at both foraging and breeding areas. Even though these temperature-dependent traits have been well studied independently, no study has taken in consideration the interaction between them to investigate the effect of thermal changes on population dynamics. We modeled the growth of embryos, hatchling sex ratio and the nesting phenology based on past climate temperature and tested several future scenarios to explore whether the temperature-dependent interplay can amplify, buffer or neutralize the effect of climate change on sea turtle embryonic development. To illustrate this, we use a case study from a loggerhead population nesting at Praia do Forte, Brazil.

PREDICTING IMPACTS OF SEA LEVEL RISE ON SEA TURTLE NESTING HABITAT ON BIOKO ISLAND, EQUATORIAL GUINEA

Callie A. Veelenturf[1], Elizabeth Sinclair[1], Shaya Honarvar[1], Frank V. Paladino[1]

[1]IPFW

Sea levels are expected to rise 18 to 59 cm by 2100, not including an additional 10-20 cm from melting glaciers. Small islands are at the greatest risk from climate change and expected effects include salinity increases with in the water table, beach erosion, sand inundation with increased tide elevation and the resulting loss in endangered sea turtle nesting habitat. Marine reptiles have evolved with natural coastal erosive processes such as high-tide flooding, accretion, and seasonal erosion, but the extreme beach modification of the past half-century is progressing at a rate faster than the generation time of some species which would reduce the ability of these animals to adapt and select genetic traits that would be important to any long term adaptation and survival. It has been estimated that the most extreme sea level rise predictions will result in inundation of 27% of Great Barrier Reef green sea turtle nesting habitat, and nesting habitat inundation is also expected in Bonaire (26%) and Barbados (32%) with a 0.5 m sea level rise. This increased beach nest inundation will undoubtedly cause decreases in reproductive output of all sea turtle species. The various beach types where sea turtles nest combined with the specific nest-site characteristics that are selected for by each species can be altered or affected in different ways by arise in sea-level. Within and amongst species there is variation in individual selection for specific beach characteristics such as beach location, length, width, height, slope, orientation, and vegetation. Based on the spatial distribution of nests within each species, the threat of sea level rise could be more severe and more imminent for some species than others. The GPS points of each nest on the beach for an entire nesting season are useful in providing a site-specific model of climate change on Bioko island and how each species will likely be affected in the upcoming years based on the different estimate of climate change from the Intergovernmental Panel on Climate Change. The shape of Bioko's beaches are characterized in this study using measurements of slope, offshore approach, elevation, etc. to be fit into a 3D model of the different climate change scenarios. 3D profiles of Bioko's sea turtle nesting beaches were constructed by collecting morphometric and contour data in an x, y, z plane 2 times over the course of the nesting season (October – February). TIN and DEM models will be used to predict sea level rise and its effects on green and leatherback sea turtle species on Bioko. We present estimates that predict a loss of 30% of Bioko's nesting beaches by 2100, with analysis up to and including March 2017 data for presentation at the symposium. In summary, this presentation will characterize sea turtle nesting beaches in Bioko to model the effects of predicted sea level rise based on current conditions and should provide critical and important management projections for generating targeted conservation plans for the future.

ENVIRONMENTAL INFLUENCE ON TESTOSTERONE PRODUCTION

Daniel Vitenson[1], Larisa Avens[2], Joanne Braun-McNeill[2], Cain Bustinza[2], Tomoharu Eguchi[1], Joe Flanagan[3], Craig A. Harms[4], Ben Higgins[2], Lyndsey Howell[2], Andy Krauss[2], Cody Macon[2], David Owens[5], Heather Seiler[2], Jeffrey A. Seminoff[1], Jeanette Wyneken[6], Camryn D. Allen[1]

[1]Marine Mammal and Turtle Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Drive, La Jolla, California 92037
[2]Southeast Fisheries Science Center, NOAA, National Marine Fisheries Service, 101 Pivers Island Road, Beaufort, NC 28516
[3]Houston Zoo Inc., 1513 Cambridge, Houston, TX 77030
[4]Department of Clinical Sciences, College of Veterinary Medicine and Center for Marine Sciences and Technology, North Carolina State University, 303 College Circle, Morehead City, NC 28557
[5]Grice Marine Lab. University of Charleston, SC at the College of Charleston, 205 Fort Johnson Road, Charleston, SC 29412
[6]Dept. of Biological Sciences, Florida Atlantic University - SC266, 777 Glades Road, Boca Raton, FL 33431-0991

Similar to many reptiles, sea turtle sex is determined by environmental conditions during incubation (temperature-dependent sex determination). However, sea turtles do not display sex-based external morphology until they reach sexual maturity. Therefore, because sea turtles lack sex chromosomes and so far, sex cannot be determined via genetic analysis, endocrinology is used to determine the sex of immature sea turtles. Although immature male turtles have higher testosterone (T) concentrations than immature females, the range of T concentrations for immature males and females can vary seasonally within a population and are likely influenced by extraneous factors (e.g. water temperature). In this study, we investigated the effects of water temperature on T concentration in captive-reared two-year-old (28.5 – 33.9 cm SCL) loggerhead sea turtles. Laparoscopies identified 20 males and 20 females; control (held at a constant temperature, ~29°C) and experimental (28 – 15°C, dropping 1°C every 3 days) groups contained 10 turtles of each sex. Turtles were housed in individual enclosures within larger tanks and maintained under environmentally-controlled conditions allowing only temperature to vary. Blood was collected from all turtles every third day prior to the commencement of the next temperature decrease for the experimental group. Here we explore differences in T observed between the control (constant temperature) and experimental (varying temperature) groups. Our results confirm the value of T ELISA for predicting sex for immature turtles throughout the year, regardless of season and water temperature. Further, we provide insights about the potential influence of climate change-induced temperature shifts on hormone levels, the impacts of which underscore the importance of obtaining baseline population sex ratio data to better understand potential, future changes.

CLIMATIC EXTREMES AND THE FATES OF NESTS AND HATCHLINGS: EMPIRICAL MEASURES IDENTIFY CRYPTIC EFFECTS*

Jeanette Wyneken[1], David Anderson[2], Alexandra Lolavar[1], Kirt Rusenko[2], Michael Salmon[1]

[1]*Florida Atlantic University*
[2]*Gumbo Limbo Nature Center*

We systematically instrumented nests of *Caretta caretta*, *Chelonia mydas*, and *Dermochelys coriacea* with temperature data loggers across multiple (7-12) nesting seasons and sampled across the entire nesting season at a long-term study site in Boca Raton, Florida USA. Our thermal and nest success data span normal seasons, hot and wet seasons, and hotter and drier seasons, designated as such by the National Weather Service and by our empirical measurements. In the past 7 seasons, 4 years were hotter and drier than normal, setting records. The years 2010, 2011, 2015 and 2016 were particularly hot, with extended dry periods; 2016 was exceptional in its deleterious effects on eggs resulting in the complete failure of many nests. A few nests produced small numbers of hatchlings that were able to swim, but then died revealing a suite of internal defects. Across years, we correlated extreme weather events with developmental failure, high hatchling mortality in the nest, and delayed mortality of the surviving hatchlings detected because they were maintained in our lab after emergence. We suspect that hot and dry conditions can lead to cryptic deleterious effects, such that hatchlings that successfully emerge and enter the water may have lower probabilities of survival at sea than hatchlings from nests incubating under less extreme conditions. In 2015 and 2016, we measured the highest nest temperatures to date in nests of the three species. In most cases, development stops at high temperatures and the embryos die during the early embryonic stages when the nest is hot and dry. Other effects include entrapment of hatchlings beneath unhatched eggs and within egg chambers that are surrounded by relatively impermeable sand that is drought and salt-hardened. We documented and compared hatching success with the thermal environment in the nests and weather data. Further, a subset of hatchlings that emerged was collected for sex identification and results identified an exceptionally high female bias in hot, dry years.

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