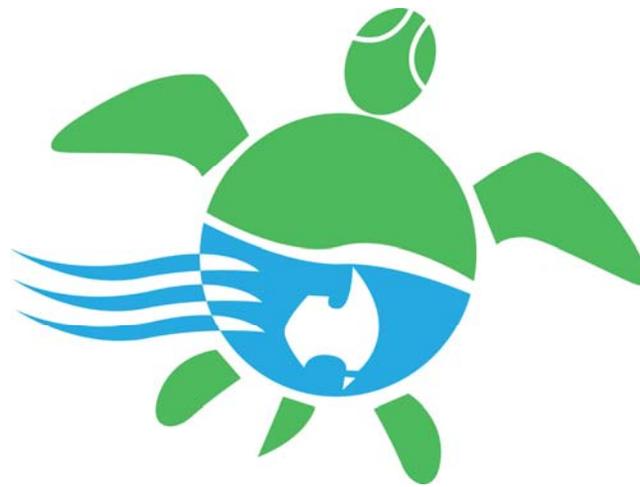




NOAA Technical Memorandum NMFS-SEFSC-630

# **PROCEEDINGS OF THE TWENTY-NINTH ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION**



17 to 19 February 2009  
Brisbane, Queensland, Australia

Compiled by:

Lisa Belskis, Mike Frick, Aliko Panagopoulou, Alan Rees, & Kris Williams

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

May 2012





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U.S. DEPARTMENT OF COMMERCE  
John Bryson, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION  
Dr. Jane Lubchenco, Under Secretary for Oceans and Atmosphere

NATIONAL MARINE FISHERIES SERVICE  
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May 2012

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| <b>Symposium Secretariat</b>                             | Suellen Holland – ICMS Australasia   |
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| <b>Poster Session Chair</b>                              | Jason van de Merwe   |
| <b>Student Awards</b>                                    | Lisa Campbell, Matthew Godfrey, & Jeanette Wyneken   |
| <b>Auction chair</b>                                     | Jennifer Homcy   |
| <b>Auctioneer</b>  | Rod Mast   |
| <b>Travel Committee Chair</b>                            | Hoyt Peckham   |
| <b>Travel Regional Chairs</b>                            | Karen Eckert, Alejandro Fallabrino, Angela Formia, Nick Pilcher, Kartik Shanker, Aliko Panagopoulou, Bryan Wallace   |
| <b>Volunteer Chairs</b>                                  | Michelle Boyle & Mark Hamann   |
| <b>Australian Sea Turtles Mini-symposium</b>             | Kiki Dethmers, Mick Guinea & Frank Loban   |
| <b>Indigenous Talking Circle</b>                         | Scott Whiting  |
| <b>RETOMALA (Latin American)</b>                         | Ana Barragán, Alejandro Fallabrino   |
| <b>South East Asia Meeting</b>                           | Karen Arthur, Kiki Dethmers  |
| <b>Mediterranean Meeting</b>                             | Paolo Casale   |
| <b>Africa Meeting</b>                                    | Jacques Fretey, Manjula Tiwari   |
| <b>Western Pacific Regional Leatherback Meeting</b>      | Peter Dutton, Manjula Tiwari   |
| <b>Pacific Islands Region Meeting</b>                    | Lui Bell   |
| <b>IUCN Marine Turtle Specialist Group</b>               | Nick Pilcher, Rod Mast   |
| <b>Freshwater Turtle Symposium</b>                       | Arthur Georges, Chuck Shaffer, Kate Hodges & Deb Bower   |
| <b>Workshops</b> – stable isotopes, statistics, necropsy | Karen Arthur, Mark Flint, Tomoharu Eguchi, Kim Reich, Jeff Seminoff  |

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| Ana Rebeca Barragan | 2011 |
| Naoki Kamezaki      | 2011 |
| Jean Beasley        | 2012 |
| Marydele Donnelly   | 2012 |
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On behalf of the ISTS we gratefully acknowledge and thank all our sponsors; exhibitors, vendors, and contributors for the continued and valued support of the 29th Symposium.

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## **STUDENT AWARDS**

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There were 103 student presentations – 39 papers and 64 posters with \$3,000 US awarded to eight recipients. The awards committee was composed of Lisa Campbell, Matthew Godfrey, Jeanette Wyneken. Judges were Karen Arthur, Ken Lohmann, Melissa Snover, Dave Owens, Annette Broderick, Sheryan Epperly, Kirstin Fritsches, Thane Wibbels, Zoe Meletis, Bryan Wallace, Nick Pilcher, Kiki Dethmers, Marydelle Donnelly, Anna Barragan and Andrea Phillott. The awards were financed by the Chelonian Research Foundation and the International Sea Turtle Society.

### **ORAL PRESENTATIONS**

#### **Best Biology Oral Presentation**

First Prize: **Wendy Dow**, Duke University, USA

In-water and in-air hearing sensitivity of the juvenile green sea turtle (*Chelonia mydas*).

Runner up: **Hoyt Peckham**, UC Santa Cruz, USA

Demographic and conservation implications of alternative foraging strategies in juvenile loggerhead turtles.

#### **Best Conservation Oral Presentation**

First Prize: **David Pike**, University of Sydney, Australia

Climatic change and changes in sea turtle nesting distributions.

Runner up: **Mariana MPB Fuentes**, James Cook University, Australia

Assessing the vulnerability of key sea turtle rookeries to predicted geographic shifts in cyclone activity.

### **POSTER PRESENTATIONS**

#### **Best Biology Poster Presentation**

First Prize: **Suzanne E Roden**, NOAA Fisheries - Southwest Fisheries Science Center / University of San Diego, USA. Detecting green turtle population structure in the Pacific using single nucleotide polymorphisms (snps).

Runner up: **Kimberly Reich**, University of Florida, USA

Effects of repeated tissue sampling on the growth of immature loggerhead turtles; a controlled study.

#### **Best Conservation Poster Presentation**

First Prize: **Juan Patiño-Martínez**, Estación Biológica de Doñana. Spain

The accumulation of driftwood on the beach disturb leatherback nesting and newborn behaviour affecting reproductive success.

Runner up: **Antonio Nogueira**, Wildlife Conservation Society

The use of geographic information system (GIS) for the support of the marine turtle research and conservation in Soyo, northern Angola.

## TABLE OF CONTENTS

---

|   |     |
|---|-----|
| COMMITTEES, CHAIRS, AND KEY ORGANIZERS.....   | iii |
| EXECUTIVE COMMITTEE AND BOARD ORGANIZERS..... | iv  |
| SPONSORS AND CONTRIBUTORS.....                | v   |
| STUDENT AWARDS.....                           | vi  |

Abstract titles marked with an \* denote Oral Presentations

### AUSTRALIA MINI-SYMPOSIUM

|  |   |
|--|---|
| DO MANAGEMENT PLANS OR TRADITIONAL USE AND CONSERVATION AGREEMENTS REALLY CHANGE HOW MANY TURTLES ARE TAKEN BY INDIGENOUS COMMUNITIES? WORKING TOWARDS DEVELOPING REAL SUSTAINABLE TURTLE HUNTING PRACTICES IN NORTH QUEENSLAND* |   |
| <b>Ian P. Bell and James Gaston</b> .....  | 1 |
| MAKING TURTLES COUNT ON THE NSW NORTH COAST*   |   |
| <b>Marny Bonner, Keith Williams, and Rochelle Ferris</b> .....   | 1 |
| DRAFT MARINE TURTLE RECOVERY PLAN FOR WESTERN AUSTRALIA*   |   |
| <b>Tamra F. Chapman, Alan Kendrick, Keith Morris, Fran Stanley, and Marissa Speirs</b> .....   | 2 |
| A SURVEY PROGRAM TO LOCATE AND DOCUMENT THE DISTRIBUTION AND STATUS OF MARINE TURTLE NESTING AROUND THE COASTLINE OF THE NORTHERN TERRITORY OF AUSTRALIA*  |   |
| <b>Ray Chatto</b> .....  | 2 |
| THE EFFECT OF INCUBATION TEMPERATURE ON MORPHOLOGY AND RUNNING PERFORMANCE OF LOGGERHEAD SEA TURTLE HATCHLINGS FROM MON REPOS, AUSTRALIA   |   |
| <b>Cuong The Chu, David Booth, and Colin Limpus</b> .....  | 3 |
| DIET AND FEEDING BIOLOGY OF ADULT OLIVE RIDLEY ( <i>LEPIDOCHELYS OLIVACEA</i> ) AND LOGGERHEAD ( <i>CARETTA CARETTA</i> ) SEA TURTLES IN FOG BAY, NORTHERN TERRITORY, AUSTRALIA  |   |
| <b>Shaun P. Conway and Michael L. Guinea</b> .....   | 4 |
| TUDU TURTLE FORAGING POPULATION MONITORING, WAPA AND TIDIU MAZA (WARRIOR AND DUNGENESS REEF)*  |   |
| <b>Charles David, Frank Loban, and Mark Hamann</b> .....   | 4 |
| ESTIMATING NESTING SUCCESS AT A HIGH-DENSITY GREEN TURTLE ROOKERY ON RAINE ISLAND, QUEENSLAND, USING DISTANCE SAMPLING AND LINE TRANSECTS*   |   |
| <b>Nancy F. FitzSimmons, Anton D. Tucker, Duncan J. Limpus, and Colin J. Limpus</b> .....  | 5 |
| NEST DEPTH AND TEMPERATURE LIMIT THE CLUTCH SUCCESS OF FLATBACK TURTLES ON BARROW ISLAND, WESTERN AUSTRALIA  |   |
| <b>Claire Foster, Kellie Pendoley, Dorian Moro, and Harriet Mills</b> .....  | 5 |
| THE ENVIRONMENTAL PROTECTION AGENCY'S MARINE WILDLIFE STRANDING PROJECT*   |   |
| <b>Jenny Greenland</b> .....   | 6 |
| MACKAY AND DISTRICT TURTLE WATCH ASSOCIATION - BUILDING, MAINTAINING AND CONTINUING OUR COMMUNITY PARTNERSHIPS   |   |
| <b>Ken Griffin, Cath Maclean, and Mark Hamann</b> .....  | 6 |
| TWENTY YEARS OF NESTING, HATCHING AND EMERGENCE SUCCESS OF FLATBACK SEA TURTLES ( <i>NATATOR DEPRESSUS</i> ) IN THE BARE SAND ISLAND DISTRICT OF FOG BAY, NORTHERN TERRITORY, AUSTRALIA*   |   |
| <b>Michael L. Guinea</b> .....   | 7 |

|  |    |
|--|----|
| THE MONITORING, CONSERVATION & SECURING THE FUTURE OF FLATBACK TURTLES<br>( <i>NATATOR DEPRESSUS</i> ) IN PORT HEDLAND, WESTERN AUSTRALIA*   |    |
| <b>Kelly Howlett</b> .....   | 7  |
| QUEENSLAND TURTLE CONSERVATION PROJECT: AVOID ISLAND FLATBACK TURTLE<br>STUDY 2007-2008*   |    |
| <b>Michelle Jones and Janene Metcalfe</b> .....  | 8  |
| INDIGENOUS MANAGEMENT OF MARINE TURTLES IN NORTHERN AUSTRALIA*   |    |
| <b>Rod Kennett, Daniel Oades, Kevin George, Frank Loban, Lachlan Sutherland, Tonya Murray, Vanessa Walsh,<br/>Libby Larsen, Balapulu Yunupingu, Chris Roberts, Steve Johnson, and Graham Friday</b> .....  | 9  |
| GREEN TURTLE NESTING POPULATION MONITORING, MAIZAB KAUR (BRAMBLE CAY)*   |    |
| <b>Frank Loban, Eddie Sailor, and Kristen Weis</b> .....   | 9  |
| INDIGENOUS HUNTING OF MARINE TURTLES IN AUSTRALIA: CONSERVATION CHALLENGE<br>OR OPPORTUNITY?*  |    |
| <b>Helene Marsh</b> .....  | 10 |
| WESTERN AUSTRALIA'S NINGALOO TURTLE PROGRAM: COST-EFFECTIVE THREAT-BASED<br>CONSERVATION INVOLVING COMMUNITY, GOVERNMENT AND NON-GOVERNMENT<br>ORGANISATIONS*  |    |
| <b>Roland Mau, Susie Bedford, David Waayers, Raquel Carter, Kate Macgregor, Paul Gamblin, Catherine<br/>Samson, Kim Onton, Brooke Halkyard, and Amy Lewis</b> .....  | 11 |
| COMMUNITY INVOLVEMENT: THE ROAD FROM VOLUNTEERING TO SCIENTIFIC SPECIES<br>GAIN  |    |
| <b>Glenn C. McFarlane</b> .....  | 12 |
| COMMUNITY PARTICIPATION IN ECOLOGICAL MONITORING: THE BENEFITS OF USING<br>VOLUNTEERS TO DETERMINE FLATBACK TURTLE POPULATION SIZE ON BARROW<br>ISLAND*  |    |
| <b>Dorian Moro</b> .....   | 12 |
| FLATBACK TURTLES: SPATIAL DISTRIBUTION AND REPRODUCTIVE BIOLOGY IN THE<br>PILBARA REGION OF WESTERN AUSTRALIA*   |    |
| <b>Kellie Pendoley, Milani Chaloupka, and Jessica Oates</b> .....  | 13 |
| SEA TURTLES IN THE WESTERN AUSTRALIAN REGION: WHAT DO WE NOW KNOW/STILL<br>NEED?*  |    |
| <b>Robert Prince</b> .....   | 14 |
| PROTECTING WESTERN AUSTRALIAN SEA TURTLES THROUGH GOVERNMENT AND<br>INDUSTRY PARTNERSHIPS  |    |
| <b>Fran Stanley, Robert I.T. Prince, Geoff Kregor, and Marissa Speirs</b> .....  | 14 |
| GREEN TURTLE INTERTIDAL BASKING AGGREGATION FIDELITY IN GREAT SANDY<br>MARINE PARK*  |    |
| <b>Aub Strydom</b> .....   | 15 |
| COLLABORATIVE APPROACH TO MARINE TURTLE CONSERVATION AND TOURISM IN THE<br>NINGALOO REGION, WESTERN AUSTRALIA*   |    |
| <b>David A. Waayers</b> .....  | 15 |
| DOWAR TURTLE NESTING POPULATION MONITORING   |    |
| <b>Moses Wailu and Frank Loban</b> .....   | 16 |
| COOLUM COAST CARES-TURTLE TROUBLES   |    |
| <b>Leigh Warneminda, Michelle Jones, Sherida Holford, and Susan Richards</b> .....   | 17 |
| LOOKING AFTER SEA TURTLES IN THE NORTHERN TERRITORY: SEA RANGERS,<br>COMMUNITIES, SCHOOL KIDS AND SCIENCE*   |    |
| <b>Scott D. Whiting, Stephen Johnson, Graeme Friday, Thomas Simon, Damian Pracy, Samuel Evans, Felicity<br/>Chapman, Gavin Enever, Simon Hartley, Simeon Lalara, Nathan Barra, David Campbell, Kate Hadden, Jack<br/>Long, Anthony Kleidon, Ray Chatto, Libby Larsen, Anderson Lauder, and Karen Edyvane</b> ..... | 17 |
| DIVE! DIVE! DIVE! A FIRST ACCOUNT OF THE BEHAVIOUR OF YOUNG FLATBACK TURTLES<br>IN THE FIELD*  |    |
| <b>Jeanette Wyneken, Mark Hamann, and Michael Salmon</b> .....   | 18 |

## **BREEDING BIOLOGY**

|   |    |
|---|----|
| BODY WEIGHT AND THE ENERGY BUDGET OF GRAVID HAWKSBILL TURTLES<br>( <i>ERETMOCHELYS IMBRICATA</i> ) DURING THE NESTING SEASON<br><b>Armando Barsante, Eliza M. X. Freire, Claudio Bellini, and Gilberto Corso</b> .....  | 19 |
| A TRI-NATIONAL AERIAL SURVEY OF LEATHERBACK NESTING ACTIVITY IN NEW GUINEA<br>AND THE SOLOMON ISLANDS<br><b>Scott Benson, Vagi Rei, Creusa Hitipeuw, Betuel Samber, Ricardo Tapilatu, John Pita, Peter Ramohia, Patrick<br/>Pikacha, Joe Horoku, Bas Wurlanty, and Barry Krueger</b> .....                      | 19 |
| THE EFFECT OF RELOCATION AND KEY ENVIRONMENTAL FACTORS ON LOGGERHEAD<br>SEA TURTLE ( <i>CARETTA CARETTA</i> ) NESTS ON CAPE ISLAND, SOUTH CAROLINA, USA*<br><b>Melissa Bimbi, Sarah Dawsey, and Derk Bergquist</b> .....  | 20 |
| FIRST EVER POPULATION CENSUS OF NESTING LOGGERHEADS ON SAL ISLAND, CABO<br>VERDE<br><b>Jacque Cozens, Manuel Pereira, Edson Mendes, and Rachel Miles</b> .....  | 21 |
| SWOT TECH SUPPORT – BRINGING THE SWOT GLOBAL SEA TURTLE DATABASE<br>ADVANCED MAPPING CAPABILITIES AND NEW UTILITIES<br><b>Andrew DiMatteo, Bryan Wallace, Ei Fujioka, Pat Halpin, and Andy Read</b> .....   | 21 |
| 50 YEARS DOWN THE WINDWARD ROAD: REFLECTIONS ON SEA TURTLE POPULATIONS AT<br>TORTUGUERO, COSTA RICA*<br><b>Emma Harrison and David Godfrey</b> .....  | 22 |
| ENCOURAGING NEWS FROM BUCK ISLAND REEF NATIONAL MONUMENT: STATUS AND<br>TRENDS IN THE NEW MILLENNIUM<br><b>Zandy Hillis-Starr and Ian F. Lundgren</b> .....   | 22 |
| SOME AGED FEMALES LACK NESTING EXPERIENCE*<br><b>Takashi Ishihara and Naoki Kamezaki</b> .....  | 23 |
| TEMPORAL AND SPATIAL EVALUATION OF NATURAL PREDATION ON THE KEMP'S<br>RIDLEY, AN ARRIBADA SPECIES<br><b>Anne M. LeBlanc, Thane Wibbels, Marco Antonio-P., Gloria Tavera , Diana J. Lira-R. , Hector J. Martinez-O.,<br/>Jaime Pena-V. , Patrick M. Burchfield , Earl Possardt , and Barbara Schroeder</b> ..... | 23 |
| PROJECT TO DETERMINE THE DISTRIBUTION AND POPULATION SIZES OF NESTING<br>MARINE TURTLES IN NEW CALEDONIA, AND TO ENHANCE THE CAPACITY OF LOCAL<br>GOVERNMENTS TO PROTECT AND MANAGE THESE SPECIES<br><b>Colin Limpus, Sophie Mounier, and Ahab Downer</b> .....   | 24 |
| SEA TURTLE NEST PREDATION DYNAMICS: IMPLICATIONS FOR CONSERVATION AND<br>MANAGEMENT*<br><b>Guilherme O. Longo, Sergio R. Floeter, Fernando D. Pazeto, and João A. G. de Abreu</b> .....   | 24 |
| TOWARD A COMPREHENSIVE MODEL TO MAXIMIZE THE PRODUCTIVITY OF HAWKSBILL<br>NESTING BEACHES: DECIDING WHERE TO RELOCATE IMPERILED NESTS AT BUCK ISLAND<br>REEF NATIONAL MONUMENT<br><b>Ian Lundgren and Zandy Hillis-Starr</b> .....  | 25 |
| THE EFFECTS OF COMMON LOGGERHEAD NEST MANAGEMENT METHODS ON NEST<br>SUCCESS ON SAPELO ISLAND, GEORGIA, USA*<br><b>Mandi L. McElroy, Mark G. Dodd, and Steven B. Castleberry</b> .....   | 25 |
| LOGGERHEAD AND ATLANTIC GREEN SEA TURTLE NESTING AND HATCHING TRENDS ON<br>EGLIN AIR FORCE BASE, FLORIDA FROM 1995 THROUGH 2008<br><b>Bob Miller and Kristin Smith</b> .....  | 26 |
| THERMAL MICROENVIRONMENTAL INFLUENCES ON THE CRITICAL INCUBATION<br>TEMPERATURE FOR OLIVE RIDLEY SEA TURTLES AT OSTIONAL, COSTA RICA<br><b>Flor de Maria Gomez Mosqueira, Mark T. Tordoir, and Roldán A. Valverde</b> .....   | 27 |
| THE USE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR THE SUPPORT OF THE<br>MARINE TURTLE RESEARCH AND CONSERVATION IN SOYO, NORTHERN ANGOLA<br><b>Antonio Nogueira, Angela Formia, Betania Ferreira, Warren Klein, Tim Bayhnam, and Howard Rosenbaum.</b>   | 27 |
| METAPOPOPULATION THEORY AND SEA TURTLES: BRIDGING OR WIDENING THE GAP?*   |    |
| <b>Lindsey Peavey, Victoria Gonzalez Carmen, and Larry Crowder</b> .....  | 28 |
| EFFECT OF STORM FREQUENCY ON THE LEATHERBACK HATCHING SUCCESS<br><b>Liliana Quiñones, Juan Patino-Martínez, and Adolfo Marco</b> .....  | 28 |

|  |    |
|--|----|
| HUNTING HATCHLINGS: ASSESSING LOGGERHEAD HATCHLING EMERGENCE AND PREDATION RATES AT A DENSELY NESTED LOGGERHEAD BEACH<br><b>Gail Schofield, Victoria Saravia, Christopher Dean, Bronwen Gill, Laurent Sourbes, Kostas A. Katselidis, Dimitris Margaritoulis, and Amalia D. Karagouni</b> ..... | 29 |
| ACTIVE MANAGEMENT  |    |
| <b>Laurent Sourbes, Gail Schofield, Kostas A. Katselidis, and Amalia D. Karagouni</b> .....  | 30 |
| TOO MANY HOT GIRLS IN PAPUA NEW GUINEA - ESTIMATING SEX RATIOS OF LEATHERBACK TURTLES<br><b>Andre Steckenreuter</b> .....  | 30 |
| POST-TSUNAMI LEATHERBACK NESTING IN SOUTH BAY, LITTLE ANDAMANS<br><b>Devi Subramaniam, Naveen Namboothri, and Kartik Shanker</b> .....   | 31 |
| EVALUATION OF NEST PREDATION ON OLIVE RIDLEY ( <i>LEPIDOCHELYS OLIVACEA</i> ) AND GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) ALONG THE INDEX BEACHES OF GUJARAT-INDIA: SIGNIFICANCE OF STAKEHOLDERS INVOLVEMENT<br><b>S.F. Wesley Sunderraj</b> .....  | 31 |
| HABITAT AND NEST DISTRIBUTION OF HAWKSBILL TURTLE ( <i>ERETMOCHELYS IMBRICATA</i> , LINNAEUS 1758) CASE STUDY: BURUNG ISLAND OF KARIMUNJAWA ISLANDS, CENTRAL JAVA, 2005<br><b>Yuliana Fitri Syamsuni, Neviaty P Zamani, and Agus Priyono</b> .....   | 32 |
| NESTING AND INCUBATION CHARACTERISTICS OF THE INDONESIAN HAWKSBILL TURTLE ( <i>ERETMOCHELYS IMBRICATA</i> ) AT SEGAMA ISLANDS IN THE JAVA SEA FOR 10 YEARS OF RESEARCH<br><b>Shinichi Tanaka, Emi Inoguchi, Jamaludin, Akil Yusuf, and Hiroyuki Sukanuma</b> .....                             | 32 |
| NESTING REPORT OF BLACK SEA TURTLE ( <i>CHELONIA MYDAS AGASSIZII</i> ) IN BAJA CALIFORNIA SUR, MEXICO<br><b>G. Tiburcio-Pintos, P. Márquez-Almansa, V. Castillo-Leggs, E. Acevedo-Ruiz, R. Marrón Fiol, J. Marrón Fiol, and S. Sankaran</b> .....  | 33 |
| CRIMINAL SCENE INVESTIGATION ON A LOGGERHEAD TURTLE NESTING BEACH: WHO ATE THE EGGS?<br><b>Sabrina Trocini, Ian Robertson, and Stuart Bradley</b> .....  | 33 |
| EIGHT NESTS RECORDED FOR A LOGGERHEAD TURTLE WITHIN A SEASON<br><b>Anton D. Tucker</b> .....   | 34 |
| GLOBAL ESTIMATE OF ARRIBADA OLIVE RIDLEY SEA TURTLES*<br><b>Roldán Valverde, Carlos Mario Orrego, Róger Blanco, Ernesto Albavera, Martha Harfush, Basudev Tripathy, and Kartik Shanker</b> .....   | 34 |
| TEN YEARS OF LEATHERBACK NEST SURVEY DATA ON ARUBA 1999-2008<br><b>Richard W. van der Wal, Edith S. van der Wal, and Sietske M. van der Wal</b> .....  | 35 |
| SEA TURTLE NESTING AND THE FLOW OF NUTRIENTS IN THE BEACH ECOSYSTEM<br><b>Hannah B. Vander Zanden, Karen A. Bjorndal, and Alan B. Bolten</b> .....   | 35 |
| EVALUATION OF HABANERO PEPPER POWDER AS A DETERRENT AGAINST MAMMALIAN PREDATORS<br><b>Ryan Welsh, Tony Tucker, Jen Beggs, Kristen Mazzarella, and Jim Grimes</b> .....   | 35 |
| SURVEY EFFORT: WHAT ARE WE REALLY MISSING WHEN WE MISS TURTLES ON THE NESTING BEACH?*  |    |
| <b>Andrea U Whiting, Colin J. Limpus, and Milani Chaloupka</b> .....   | 36 |
| THERMAL VARIATION IN LEATHERBACK NESTS IN PACUARE RESERVE, COSTA RICA<br><b>Rebecca A. Xiques, Eric Koepfler, Scott Handy, Sarah Lucas, and David Melero</b> .....   | 36 |
| GREEN TURTLES OF THE EAST PACIFIC: HOW IMPORTANT ARE THE GALAPAGOS ISLANDS?*   |    |
| <b>Patricia M. Zárate, Karen A. Bjorndal, and Alan B. Bolten</b> .....   | 37 |

## **BYCATCH AND OTHER MORTALITY**

|  |    |
|--|----|
| DISTRIBUTIONS OF INJURED LOGGERHEAD SEA TURTLES ( <i>CARETTA CARETTA</i> ) IN THE SOUTHEASTERN UNITED STATES: A 9-YEAR REGIONAL STUDY<br><b>Jesse E. Alderson, Michael D. Arendt, Al L. Segars, and David W. Owens</b> ..... | 38 |
|--|----|

|   |    |
|---|----|
| USE OF SHARK DECOYS IN REDUCING INCIDENTAL CAPTURE OF SEA TURTLES IN THE LONG-LINE FISHERY  |    |
| <b>Angela Bostwick, Benjamin M. Higgins, André M. Landry, Jr., and Marti L. McCracken</b> .....   | 39 |
| ARTISANAL FISHING GEARS AFFECTING SEA TURTLES ALONG THE SOUTHWESTERN COAST OF THE GULF OF VENEZUELA: AN UPDATE  |    |
| <b>Larry Bracho-Perez, Gabriela Delgado-Ortega, Yorman Hernández, Ma. Gabriela Montiel-Villalobos, and Hector Barrios-Garrido</b> .....   | 39 |
| SEA TURTLE BYCATCH IN THE MEDITERRANEAN: CAPTURES, MORTALITY, PRIORITIES*   |    |
| <b>Paolo Casale</b> .....   | 40 |
| THE USE OF TURTLE EXCLUDER DEVICES IN SOUTHEAST ASIA*   |    |
| <b>Bundit Chokesanguan</b> .....  | 40 |
| PROMOTION OF THE USE OF CIRCLE HOOKS IN SOUTHEAST ASIA  |    |
| <b>Bundit Chokesanguan and Somboon Siriraksophon</b> .....  | 41 |
| PELAGIC STAGE LOGGERHEAD SEX RATIO: EVIDENCE OF DIFFERENTIAL MORTALITY BETWEEN MALE AND FEMALE JUVENILES  |    |
| <b>Cláudia Delgado, Telma Ferreira, and Thomas Dellinger</b> .....  | 41 |
| THE TURTLE CSI - INTERPRETING MARINE TURTLE STRANDING DATA, WITH MARINE (FORENSIC) TAPHONOMY EXPERIMENTS*   |    |
| <b>Thomas Dellinger, Janine Karla França da Silva, and António Jorge Martins</b> .....  | 42 |
| GENERATING MORE SUPPORT TO REDUCE SEA TURTLE BYCATCH ON THE HIGH SEAS   |    |
| <b>Marydele Donnelly</b> .....  | 42 |
| HIGH JUVENILE SURVIVAL RATES OF TURTLES: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT*  |    |
| <b>Tomo Eguchi</b> .....  | 43 |
| SEA TURTLE BYCATCH REDUCTION IN THE U.S. ATLANTIC PELAGIC LONGLINE FISHERY*   |    |
| <b>Sheryan P. Epperly, Lance P. Garrison, and Lesley W. Stokes</b> .....  | 44 |
| CUMULATIVE SEA TURTLE BYCATCH ESTIMATES ACROSS US FISHERIES AND THEIR RELATIVE IMPACTS ON NESTING AND REPRODUCTIVE STOCKS   |    |
| <b>Elena Finkbeiner, Elizabeth Griffin, Bryan Wallace, and Jeffrey Moore</b> .....  | 44 |
| ASSESSING SEA TURTLE BYCATCH AND MORTALITY IN NORTH PERU: A COMMUNITY CONSERVATION INITIATIVE   |    |
| <b>Kerstin S. Forsberg</b> .....  | 45 |
| WE NEED A U.S. LAW REQUIRING TURTLE EXCLUDER DEVICES, AGAIN   |    |
| <b>Elizabeth Griffin, Michael Hirshfield, David Allison, and Beth Lowell</b> .....  | 46 |
| IMPLEMENTING CHANGE; PROGRESS AND CHALLENGES IN BYCATCH MITIGATION IN EASTERN PACIFIC LONGLINERS*   |    |
| <b>Martin A. Hall, Moises Mug, Takahisa Mituhasi, MariLuz Parga, Cleridy Lennert-Cody, Nickolas Vogel, David Ortega, Mario Jolon, Regina Sanchez, Sara Perez, Sandra Andraka, Alvaro Segura, Lucas Pacheco, Luis Zapata, Liliana Rendon, Manuel Parrales, Jorge Villavicencio, Nelly de Paz, Jairo Calderon, and Michael Valqui</b> ..... | 46 |
| THREATS TO SEA TURTLES IN BANGLADESH COASTAL AND MARINE WATERS  |    |
| <b>Mohammad Z. Islam</b> .....  | 47 |
| MARINE TURTLE BYCATCH IN THE INDUSTRIAL PRAWN TRAWL FISHERY IN THE UNITED REPUBLIC OF TANZANIA  |    |
| <b>Catharine Joynson-Hicks and Ben Ngatunga</b> .....   | 48 |
| CAN SEA TURTLE STRANDINGS BE EXPLAINED THROUGH FISHING EFFORT? A CASE STUDY FROM BCS, MEXICO  |    |
| <b>Agnese Mancini and Volker Koch</b> .....   | 48 |
| A REVIEW OF STRANDING RECORDS OF LEATHERBACK SEA TURTLE ( <i>DERMOCHELYS CORIACEA</i> ) ALONG GULF OF VENEZUELA: ARTISANAL GILLNET FISHING MAYBE IS AN IMPORTANT THREAT   |    |
| <b>María G. Montiel-Villalobos and Héctor A. Barrios-Garrido</b> .....  | 49 |
| INCIDENTAL CATCH OF THE LOGGERHEAD TURTLE, <i>CARETTA CARETTA</i> , IN THE NORTHERN TYRRHENIAN SEA (NW MEDITERRANEAN)   |    |
| <b>Luana Papetti, Simonetta Guiducci, Riccardo Sirna, Nicola Meciani, Rosario Fico, and Alessandro Ligas</b> .....  | 50 |

ACCOUNTING FOR THE INCIDENTAL CATCH OF SEA TURTLES AND OTHER PROTECTED SPECIES IN PRODUCTIVITY MEASUREMENTS: APPLICATION TO THE CA/OR DRIFT GILLNET FISHERY

|   |    |
|---|----|
| <b>Tara L. Scott</b> .....  | 50 |
| MID-WATER FLOAT SYSTEM WITH LONG FLOAT LINES TO AVOID SEA TURTLE BYCATCH*   |    |
| <b>Daisuke Shiode, Michiru Shiga, Fuxiang Hu, and Tadashi Tokai</b> .....   | 51 |
| DO HOOKS MODIFIED WITH WIRE APPENDAGES MINIMIZE DEEP HOOK INGESTION RATES IN INCIDENTALLY CAPTURED LOGGERHEAD ( <i>CARETTA CARETTA</i> ) SEA TURTLES? |    |
| <b>Lesley Stokes, Dominy Hataway, Charles Bergmann, Sheryan Epperly, and Ben Higgins</b> .....  | 51 |
| MINIMISING FISHERIES IMPACTS ON MARINE TURTLES – THE QUEENSLAND EXPERIENCE*   |    |
| <b>Andrew Thwaites, Phillip Gaffney, Claire Andersen, and Fiona Hill</b> .....  | 52 |
| IMPACT OF INGESTED MARINE RUBBISH ON STRANDED SEA TURTLES SOURCED FROM SOUTH-EASTERN QUEENSLAND, AUSTRALIA*   |    |
| <b>Kathy A. Townsend</b> .....  | 53 |
| DEVELOPING A SEA TURTLE HUMAN INTERACTION ASSESSMENT PROTOCOL FOR STRANDED SEA TURTLES IN THE US  |    |
| <b>Lisa Wright, Mark Swingle, Gwen Lockhart, Christina Trapani, and Susan Barco</b> .....   | 53 |
| SUCCESS AND CHALLENGES OF TRANSFORMING THE INDONESIA TUNA LONGLINE INDUSTRIES ON REDUCING SEA TURTLE BYCATCH*   |    |
| <b>Imam M. Zainudin and Ahmad H. Adyas</b> .....  | 54 |

**ENVIRONMENT IMPACT**

|   |    |
|---|----|
| A CASE STUDY: HEAVY METALS AT RAS AL HADD GREEN TURTLE RESERVE AREA, SULTANATE OF OMAN  |    |
| <b>Salim H. Al-Rawahy, Mahmoud Ibrahim, Abdulaziz Alkindi, and Khamis Al Dhafri</b> .....                                       | 54 |
| HIGHEST CAPTURES OF SEA TURTLES ASSOCIATED WITH ENSO EVENTS AT SAN ANDRES PORT, SOUTHERN PERU*                                  |    |
| <b>Nelly de Paz Campos, Javier Antonio Quiñones Davila, and Jorge A. Zeballos Flor</b> .....                                    | 55 |
| USING GIS TO QUANTIFY THE EFFECTS OF SEA-LEVEL RISE ON MARINE TURTLE NESTING HABITAT  |    |
| <b>Marianne R. Fish, Alfonso Lombana, and Carlos Drews</b> .....  | 55 |
| PRESENCE OF INORGANIC MATERIALS EXPELLED BY <i>CARETTA CARETTA</i>  |    |
| <b>Daniela Freggi and Maristella D'Addario</b> .....  | 56 |
| COMMUNITY ASSISTANCE TO DETERMINE THE POTENTIAL AFFECTS OF PROJECTED SEA LEVEL RISE TO MARINE TURTLES                           |    |
| <b>Mariana MPB Fuentes, Colin J. Limpus, Mark Hamann, and John Dawson</b> .....   | 56 |
| ASSESSING THE VULNERABILITY OF KEY SEA TURTLE ROOKERIES TO PREDICTED GEOGRAPHIC SHIFTS IN CYCLONE ACTIVITY*                     |    |
| <b>Mariana MPB Fuentes, Col J Limpus, Mark Hamann, and James M Moloney</b> .....  | 57 |
| A PROGRESS REPORT: NECROPSY STUDY ON THE NORTHERN OUTER BANKS OF NORTH CAROLINA   |    |
| <b>Christian L. Guerreri, David M. Sybert, Michelle Baker, and Karen Clark</b> .....  | 57 |
| TORSOOI PROJECT: REGIONAL DATABASE AND GIS FOR THE CONSERVATION OF SEA TURTLES AND THEIR HABITATS IN THE SOUTHWEST INDIAN OCEAN |    |
| <b>Claire Jean, Jérôme Bourjea, Gwenaëlle Pennober, Noël Conruyt, and Stéphane Ciccione</b> .....                               | 58 |
| SEA TURTLE RESEARCH AND CONSERVATION IN BANGLADESH WITH SPECIAL REFERENCE TO FEEDING HABITAT AND ECOLOGY                        |    |
| <b>Abu Hena M. Kamal</b> .....  | 59 |
| LIGHTING THE WAY: HATCHLING ORIENTATION ON RUSHIKULYA MASS NESTING BEACH, INDIA*  |    |
| <b>Divya Karnad, Kartik Shanker, Kavita Isvaran, and Chandrasekhar Kar</b> .....  | 59 |
| AMONG YEAR VARIATIONS AND EFFECT OF CYCLONES ON SAND TEMPERATURES AT SEA TURTLE NESTING BEACHES IN WESTERN AUSTRALIA            |    |
| <b>Gerald Kuchling</b> .....  | 60 |

|   |    |
|---|----|
| LONG-TERM EVALUATION OF LOGGERHEAD SEA TURTLE NESTING BEACH TEMPERATURES IN THE SOUTHEASTERN U.S.: IMPLICATIONS OF GLOBAL CLIMATE CHANGE ON SEA TURTLE CONSERVATION.<br><b>Jenny Estes Layton, Thane Wibbels, Anton Tucker, Jeanette Wyneken, Llewellyn Ehrhart, Ray Carthy, R. Erik Martin, Robert Ernest, Michael Bresette, Chris Johnson, Sandy Fournier, Jill Schmid, Bruce Drye, Kennard Watson, and Amanda Bryant</b> ..... | 60 |
| EFFECTS OF CLIMATE CHANGE ON SEA TURTLES: A SUMMARY FOR REGULATORY APPLICATION<br><b>Kimberly Maison</b> .....  | 61 |
| THE ACCUMULATION OF DRIFTWOOD ON THE BEACH DISTURB LEATHERBACK NESTING AND NEWBORN BEHAVIOUR AFFECTING REPRODUCTIVE SUCCESS<br><b>Juan Patino-Martínez, Adolfo Marco, and Liliana Quiñones</b> .....  | 61 |
| CLIMATIC CHANGE AND CHANGES IN SEA TURTLE NESTING DISTRIBUTIONS*<br><b>David A. Pike</b> .....  | 62 |
| PILOT STUDY OF <i>CARETTA CARETTA</i> NESTING BEACH SAND TEMPERATURE IN NEW CALEDONIA<br><b>Tyffen Chloé Read and Colin James Limpus</b> .....  | 63 |
| RELATIVE EXPOSURE INDEX: AN IMPORTANT FACTOR IN SEA TURTLE NESTING DISTRIBUTION*<br><b>Julia Santana Garcon, Alana Grech, James Moloney, and Mark Hamann</b> .....  | 63 |
| FORECASTING HATCHING SUCCESS IN AN INSULAR MARINE TURTLE ROOKERY*<br><b>Kyle S. Van Houtan and Oron L. Bass</b> .....   | 64 |
| JAGUAR PREDATION OF MARINE TURTLES: MULTILATERAL THREATS TO FLAGSHIP SPECIES AND THE NECESSITY FOR HOLISTIC CONSERVATION<br><b>Diogo Verissimo, David Jones, and Rebeca Chaverri</b> .....  | 64 |

## **FORAGING BIOLOGY**

|   |    |
|---|----|
| DISTRIBUTION OF HAWKSBILL TURTLES OFF PERU AND IMPLICATIONS FOR REGIONAL CONSERVATION EFFORTS<br><b>Joanna Alfaro-Shigueto, Jeffrey Mangel, Kerstin Forsberg, Anand Ramanathan, Celia Caceres, Peter Dutton, Jeffrey Seminoff, and Brendan Godley</b> .....                     | 65 |
| FORAGING GROUNDS OF GORGONA (COLOMBIA) AND THEIR IMPORTANCE FOR GREEN SEA TURTLES ( <i>CHELONIA MYDAS</i> ) IN THE EAST PACIFIC*<br><b>Diego F. Amorocho and Richard D. Reina</b> .....   | 65 |
| HABITAT USE AND FOOD INTAKE OF GREEN TURTLES ( <i>CHELONIA MYDAS</i> ) FORAGING ON A MULTISPECIFIC SEAGRASS BED AT MAYOTTE ISLAND*<br><b>Katia Ballorain, Stéphane Ciccione, Jérôme Bourjea, Manfred Enstipp, Henri Grizel, and Jean-Yves Georges</b>                           | 66 |
| DIET OF PELAGIC LOGGERHEAD SEA TURTLES ( <i>CARETTA CARETTA</i> ) IN SOUTHERN BRAZIL<br><b>Juliana A. Barros, Eduardo R. Secchi, Danielle S. Monteiro, and Sérgio C. Estima</b> .....   | 67 |
| UNDERWATER PHOTOGRAPHY AS A WINDOW INTO HAWKSBILL FORAGING BIOLOGY AND BEHAVIOUR<br><b>Janice Blumenthal, Timothy Austin, Catherine Bell, John Bothwell, Annette Broderick, Gina Ebanks-Petrie, James Gibb, Jeremy Olynik, Mark Orr, Joni Solomon, and Brendan Godley</b> ..... | 67 |
| SEA TURTLES IN THE GLOVER'S REEF MARINE RESERVE, BELIZE: CHARACTERISTICS AND CONSERVATION IMPLICATIONS<br><b>Cathi L. Campbell, Robin Coleman, Roberto Carballo, and Janet P. Gibson</b> .....  | 68 |
| A STUDY OF THE HAWKSBILL ( <i>ERETMOCHELYS IMBRICATA</i> ) AND GREEN TURTLES ( <i>CHELONIA MYDAS</i> ) FORAGING ON THE REEFS OF TOBAGO, W.I.; DISTRIBUTION, ABUNDANCE AND AN ASSESSMENT OF THEIR VALUE*<br><b>Michelle Cazabon</b> .....  | 68 |
| FORAGING ECOLOGY PATTERNS OF THE MOSQUITO LAGOON JUVENILE GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) POPULATION FROM 1978 TO PRESENT: REFLECTIONS OF A HEALTHY SEAGRASS HABITAT?<br><b>Karen G. Holloway-Adkins and Jane A. Provancha</b> .....                                     | 69 |

FOOD HABITS OF JUVENILE GREEN SEA TURTLES (*CHELONIA MYDAS*) ALONG THE MIDDLE AND LOWER TEXAS COAST

**Lyndsey N. Howell, Andre M. Landry, Jr., and Donna J. Shaver** .....69  
AERIAL SURVEYS OF MARINE TURTLES ALONG THE WEST COAST OF REUNION ISLAND  
**Claire Jean, Stéphane Ciccione, Katia Ballorain, Jean-Yves Georges, and Jérôme Bourjea** .....70  
ABUNDANCE, SIZE CLASSES, GROWTH RATES, AND CONDITION OF FORAGING GREEN SEA TURTLES, *CHELONIA MYDAS*, AT JOHN BREWER’S BAY, ST. THOMAS, U.S. VIRGIN ISLANDS.  
**Kemit-Amon Lewis and William Coles** .....71  
KEMP’S RIDLEY SEA TURTLES IN ST. JOSEPH BAY, FLORIDA, USA: RESULTS FROM AN IN-WATER STUDY IN THE NORTHEASTERN GULF OF MEXICO  
**Erin McMichael, Jeffrey A. Seminoff, Russell A. Scarpino, and Ray Carthy** .....71  
STABLE ISOTOPE DICHOTOMY IN LOGGERHEAD TURTLES REVEALS PACIFIC-ATLANTIC OCEANOGRAPHIC DIFFERENCES\*  
**Mariela Pajuelo, Karen A. Bjørndal, Alan B. Bolten, Jeffrey Seminoff, and Joanna Alfaro-Shigueto** .....72  
DEMOGRAPHIC AND CONSERVATION IMPLICATIONS OF ALTERNATIVE FORAGING STRATEGIES IN JUVENILE LOGGERHEAD TURTLES\*  
**Hoyt Peckham, Yann Tremblay, David Maldonado-Díaz, Ruth Ochoa, Jeffery Polovina, Peter Dutton, Daniel Costa, Barbara Block, and Wallace J. Nichols** .....73  
EFFECT OF FOOD RESOURCES AND SHELTER ON THE ABUNDANCE AND DISTRIBUTION OF HAWKSBILL TURTLES, *ERETMOCHELYS IMBRICATA*, IN CARIBBEAN CORAL REEFS  
**Patricia Rincón-Díaz, Alberto Sabat, Carlos E. Diez, and Robert van Dam** .....73  
ABUNDANCE ESTIMATES AND HABITAT PREFERENCES FOR LOGGERHEAD TURTLE (*CARETTA CARETTA*) OFF SOUTHERN SPAIN: IMPLICATIONS FOR CONSERVATION\*  
**Lucia Rueda, Ana Cañadas, Ricardo Sagarminaga, and Steve Cadrin** .....74  
SIZE DISTRIBUTION OF GREEN TURTLES (*CHELONIA MYDAS*) FOUND AROUND THE COAST OF JAPAN INDICATED FROM BYCATCH AND STRANDING DATA  
**Takahiro Shimada, Takashi Ishihara, Kano Miyauchi, Yuka Takeuchi, and Naoki Kamezaki** .....75  
AGE AND GROWTH RATES FOR HAWAIIAN HAWKSBILLS USING SKELETOCHRONOLOGY  
**Melissa L. Snover and George H. Balazs** .....75  
LIGHTS, CAMERA, ACTION: UTILIZING A PHOTOGRAPHIC CATALOG AS A TOOL FOR THE IDENTIFICATION OF HAWKSBILL SEA TURTLES  
**Mollie E. Tubbs, Lawrence Wood, and Richard Snider** .....76  
MULTI-YEAR OBSERVATIONS OF GREEN TURTLES (*CHELONIA MYDAS*) IN A NEARSHORE HARBOTTOM HABITAT OF PALM BEACH ISLAND, FLORIDA, USA  
**Lawrence D. Wood and Stephen M. Shelb** .....76  
AGE AND GROWTH OF LOGGERHEAD TURTLE FROM COASTAL SOUTH CAROLINA ESTIMATED FROM MARK-RECAPTURE DATA  
**Beth M. Wrege, Philip P. Maier, and J. Jeffery Isely** .....77

**GENETICS AND STOCK RECOGNITION**

MOLECULAR GENETIC LINK OF GREEN SEA TURTLES (*CHELONIA MYDAS*) FROM DERAWAN ISLANDS-INDONESIA WITH AUSTRALASIAN POPULATION\*

**Ni Kadek Dita Cahyani, IGNK Mahardika, Ximena Velez Zuazo, and Ketut Sarjana Putra** .....77

GENETIC DIVERSITY OF THE GREEN TURTLE (*CHELONIA MYDAS*) POPULATIONS IN SRI LANKA

**E.M.L. Ekanayake, R.S. Rajakaruna, P. Samaraweera, K.B. Ranawana, T. Kapurusinghe, M.M. Saman, and M.G.C. Premakumara** .....78

STANDARDIZING THE MTDNA CONTROL REGION FRAGMENT FOR SEA TURTLES: HOW LONG DO SEQUENCES NEED TO BE?

**Amy Frey, Peter Dutton, Erin LaCasella, Robin LeRoux, and Alberto Abreu-Grobois** .....79

POPULATION STRUCTURE OF OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) IN THE ATLANTIC OCEAN USING MICROSATELLITE MARKERS\*

**Anelise T. Hahn, Jaqueline C. de Castilhos, Luciano S. Soares, Brian W. Bowen, and Sandro L. Bonatto** .....79

|   |    |
|---|----|
| LOW MTDNA DIVERSITY OF THE BRAZILIAN NESTING POPULATIONS OF OLIVE RIDLEY TURTLES ( <i>LEPIDOCHELYS OLIVACEA</i> )<br><b>Anelise Torres Hahn, Luiza B. Fernandes, Felipe G. Grazziotin, Jaqueline C. de Castilhos, and Sandro L. Bonatto</b> .....                 | 80 |
| NEW INSIGHTS INTO THE COMPOSITION OF GREEN TURTLE FEEDING GROUNDS IN THE NORTHERN GREAT BARRIER REEF*<br><b>Michael Jensen, Nancy N. FitzSimmons, Mark Hamann, Charles David, Stephen Ambar, Ian Bell, and Colin J. Limpus</b> .....                              | 80 |
| EVALUATION OF DNA EXTRACTION METHODS ON SEA TURTLE TISSUE: HOW MUCH DO WE NEED BEFORE SACRIFICING QUALITY OVER QUANTITY?<br><b>Amy K. Jue, Peter H. Dutton, Robin A. LeRoux, Erin L. LaCasella, Amy Frey, Suzanne E. Roden, and Amanda Bowman</b> .....           | 81 |
| STOCK ORIGIN OF LEATHERBACKS ( <i>DERMOCHELYS CORIACEA</i> ) FORAGING OFF CENTRAL CALIFORNIA, USA<br><b>Erin L. LaCasella, Peter H. Dutton, Scott R. Benson, Robin A. LeRoux, and Suzanne E. Roden</b> .....  | 82 |
| RE-EXAMINING CARIBBEAN HAWKSBILL POPULATION STRUCTURE USING LONGER MTDNA SEQUENCES<br><b>Robin A. LeRoux, Peter H. Dutton, F. Alberto Abreu-Grobois, Cynthia J. Lagueux, Cathi L. Campbell, Julia A. Horrocks, Zandy Hillis-Starr, and Sebastian Troëng</b> ..... | 82 |
| NATAL ORIGIN OF JUVENILE LOGGERHEAD TURTLES FROM FORAGING GROUNDS IN NICARAGUA AND PANAMA WITH NEWLY SUGGESTED MITOCHONDRIAL DNA PRIMERS<br><b>Akiko Masuda, Tag N. Engstrom, Cathi L. Campbell, and Cynthia J. Lagueux</b> .....                                 | 83 |
| INCREASED GENETIC VARIATION UNCOVERED IN LOGGERHEAD TURTLES FROM QUINTANA ROO, MEXICO AND ST. GEORGE ISLAND, FLORIDA<br><b>Janne T. Nielsen, F. Alberto Abreu-Grobois, Alejandro Arenas, and Michael S. Gaines</b> .....  | 83 |
| DETECTING GREEN TURTLE POPULATION STRUCTURE IN THE PACIFIC USING SINGLE NUCLEOTIDE POLYMORPHISMS (SNPS)<br><b>Suzanne E. Roden, Peter H. Dutton, Phillip A. Morin, George H. Balazs, Patricia Zarate, and I. Juinn Cheng</b> .....                                | 84 |
| GENETIC POPULATION STRUCTURE WITHIN THE FLORIDA GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) ROOKERY*<br><b>Brian M. Shamblin, Dean A. Bagley, Llewellyn M. Ehrhart, R. Erik Martin, Niki Desjardin, Laura Wright, and Campbell J. Nairn</b> .....                      | 84 |
| CURRENT BIOGEOGRAPHY OF BLACK SEA TURTLE POPULATION ( <i>CHELONIA MYDAS AGASSIZII</i> ) IN THE EAST PACIFIC: TECTONIC AND PALEOMAGNETIC PERSPECTIVE<br><b>Carlos Delgado Trejo, Jaime Urrutia Fucugauchi, and Javier Alvarado Diaz</b> .....                      | 85 |
| SPECIES-SPECIFIC MICROSATELLITE ALLELES INDICATING INTROGRESSION IN SEA TURTLE SPECIES<br><b>Sarah M. Vargah, Luciano S. Soares, and Fabrício R. Santos</b> .....   | 85 |

## **HEALTH, PHYSIOLOGY AND TOXICOLOGY**

|   |    |
|---|----|
| BACTERIA FLORA FROM THE OVIDUCTAL FLUID IN THE GREEN TURTLE, <i>CHELONIA MYDAS</i> WITH REFERENCE TO ANTIBIOTIC RESISTANCE<br><b>SN Al-Bahry, MA Al-Zadjali, IY Mahmoud, AE Elshafie, A Al-Harthy, W Al-Alawi, AY Alkindi, and SH Al-Rawahi</b> ..... | 86 |
| PLASMA ESTRADIOL AND PROGESTERONE LEVELS DURING EMBRYONIC AND POST HATCHING PERIODS IN THE GREEN TURTLE ( <i>CHELONIA MYDAS</i> )<br><b>AlKindi, AYA, Al-Bahry, SN, Mahmoud, IY, Al-Omairi, R, Al-Amri, I, Al-Rawahy, S.H., and Khan, T</b> .....     | 87 |
| BLOOD LEVELS OF COPPER, LEAD AND MERCURY IN GREEN SEA TURTLES ( <i>CHELONIA MYDAS</i> ) PRESENT IN TWO CONGREGATION SITES ON THE NORTHERN CHILE<br><b>Rocío E. Alvarez, Mauricio Fabry, Carlos A. Alvear, and Carlos Guerra</b> .....                 | 87 |
| IN-WATER AND IN-AIR HEARING SENSITIVITY OF THE JUVENILE GREEN SEA TURTLE ( <i>CHELONIA MYDAS</i> )*<br><b>Wendy E. Dow, David A. Mann, T. Todd Jones, Scott A. Eckert, and Craig A. Harms</b> .....   | 88 |

|  |    |
|--|----|
| DEVELOPMENT OF A STRATEGY TO STUDY THE TOXICODYNAMICS OF POLLUTANTS IN BREEDING SEA TURTLES FROM THE FRENCH WEST INDIES<br><b>Christelle Dyc, Claire Cayol, Marie-Claire DePauw, Cathy Debier, Eric Delcroix, Jean-Pierre Thomé, Jean-Marie Bouqueneau, and Krishna Das</b> .....                              | 89 |
| BACTERIAL CONTAMINATION AND COLONIZATION WITH REFERENCE TO ANTIBIOTIC RESISTANCE IN THE EGG COMPONENT OF THE GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) IN OMAN<br><b>Abdulkadir Elshafie, Saif Al-Bahry, Ibrahim Mahmoud, Asila Al-Harthy, Sabha Al-Gharfri, Abdulaziz Alkindi, and Issa al-Amri</b> .....        | 89 |
| DEVELOPMENT OF CORNEAL FIBROPAPILLOMATOSIS IN GREEN TURTLES ( <i>CHELONIA MYDAS</i> ) IN QUEENSLAND AUSTRALIA<br><b>Mark Flint, Colin J. Limpus, Janet C. Patterson-Kane, Peter J. Murray, and Paul C. Mills</b> .....   | 90 |
| USING PLASMA BIOCHEMISTRY AND HAEMATOLOGICAL BLOOD REFERENCE RANGES AS A TOOL IN DIAGNOSING DISEASE FOR GREEN TURTLES ( <i>CHELONIA MYDAS</i> ) IN QUEENSLAND, AUSTRALIA*<br><b>Mark Flint, John Morton, Janet C. Patterson-Kane, Colin J. Limpus, Peter J. Murray, and Paul C. Mills</b> ...                  | 90 |
| RESPONSE OF SEA TURTLE HATCHLINGS TO LIGHTS OF DIFFERENT COLOUR*<br><b>Kerstin A. Fritsches</b> .....  | 91 |
| COMPARATIVE HEALTH ASSESSMENT OF WESTERN PACIFIC LEATHERBACK TURTLES ( <i>DERMOCHELYS CORIACEA</i> ) FORAGING OFF THE COAST OF CALIFORNIA, 2005-2007*<br><b>Heather S. Harris, Scott R. Benson, Peter H. Dutton, Kirsten V. Gilardi, Robert H. Poppenga, Thierry M. Work, and Jonna A. K. Mazet</b> .....      | 92 |
| THE EFFECT OF HEAVY METALS ON STEROID AND METABOLITE CONCENTRATIONS IN NESTING <i>NATATOR DEPRESSUS</i><br><b>Maria P. Ikononopoulou, Adrian Bradley, and Joan Whittier</b> .....  | 92 |
| CONTAMINANT LEVELS, BIOACCUMULATION AND HEALTH EFFECTS IN <i>CHELONIA MYDAS</i> IN SAN DIEGO BAY, CA*<br><b>Lisa Komoroske, Rebecca Lewison, and Peter H. Dutton</b> .....   | 93 |
| BODY CONDITION FOR THE BLACK TURTLE, <i>CHELONIA MYDAS AGASSIZII</i> , IN BAJA CALIFORNIA SUR, MÉXICO<br><b>Vanessa Labrada-Martagón, Lia Méndez-Rodríguez, Susan C. Gardner, Tania Zenteno-Savín, and Victor H. Cruz-Escalona</b> .....   | 93 |
| BLOOD BIOCHEMISTRY VALUES OF THE BLACK TURTLE, <i>CHELONIA MYDAS AGASSIZII</i> , IN THE OCCIDENTAL COAST OF BAJA CALIFORNIA<br><b>Vanessa Labrada-Martagón, Lia Méndez-Rodríguez, Susan C. Gardner, Tania Zenteno-Savín, and Melania López</b> .....   | 94 |
| CHANGES IN ULTRASTRUCTURE OF EGGSHELL DURING DIFFERENT PERIODS OF INCUBATION IN THE GREEN TURTLE, <i>CHELONIA MYDAS</i> , AT RAS AL-HADD<br><b>IY Mahmoud, SN Al-Bahry, IS Al-Amri, IY AlKindi, AE Elshafie, and SH Al-Rawahi</b> .....  | 95 |
| AUDITORY EVOKED POTENTIALS OF LOGGERHEAD ( <i>CARETTA CARETTA</i> ) AND GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) HATCHLINGS AND POST-HATCHLINGS*<br><b>Kelly J. Martin, David A. Mann, and Sarah C. Alessi</b> .....   | 95 |
| HISTOLOGY ATLAS OF LOGGERHEAD SEA TURTLES, <i>CARETTA CARETTA</i><br><b>Jorge Martins, Cláudia Delgado, Paulo Vaz Pires, and Thomas Dellinger</b> .....  | 96 |
| DO PIT TAGS MIGRATE IN SEA TURTLE FLIPPERS?<br><b>Erin McMichael, Jeanette Wyneken, Ben Higgins, Sheryan Epperly, and Joe Flanagan</b> .....   | 96 |
| PERFLUORINATED CONTAMINANT CONCENTRATIONS IN LOGGERHEAD SEA TURTLES: EXPANDED SPATIAL AND TEMPORAL TRENDS ALONG THE EAST COAST OF THE UNITED STATES*<br><b>Steven G. O'Connell, Tricia Kimmel, Joanne Braun-McNeill, Larisa Avens, Al Segars, Mike Arendt, Barbara Schroeder, and Jennifer M. Keller</b> ..... | 97 |
| CARAPACIAL SCUTES OF HAWKSBILL TURTLES: UNLOCKING THE SECRETS WITHIN<br><b>Pushpa M. Palaniappan, Grahame J. W. Webb, and S. Charlie Manolis</b> .....   | 98 |
| A RETROSPECTIVE STUDY OF HISTOLOGICAL LESIONS IN STRANDED SEA TURTLES IN THE GOLD COAST REGION, QUEENSLAND*<br><b>Janet C. Patterson-Kane, Mark Flint, Paul C. Mills, Colin J. Limpus, and David Blyde</b> .....   | 98 |

|  |     |
|--|-----|
| MATERNAL INVESTMENTS: MERCURY AND SELENIUM IN HATCHLING LEATHERBACK SEA TURTLES ( <i>DERMOCHELYS CORIACEA</i> V.) AND THEIR MOTHERS*   |     |
| <b>Justin Perrault, Jeanette Wyneken, Larry J. Thompson, Chris Johnson, and Debra L. Miller</b> .....  | 99  |
| BLOOD CHEMISTRY VALUES ON LOGGERHEAD SEA TURTLE ( <i>CARETTA CARETTA</i> ): FLUCTUATIONS IN COMPARISON OF CLINICAL CONDITIONS AND SAMPLE TECHNIQUES  |     |
| <b>Angelo Quaranta, Antonio Di Bello, Daniela Freggi, Giuseppe Vitucci, and Salvatore Dimatteo</b> .....   | 100 |
| EFFECTS OF REPEATED TISSUE SAMPLING ON THE GROWTH OF IMMATURE LOGGERHEAD TURTLES; A CONTROLLED STUDY   |     |
| <b>Kimberly J. Reich, Karen A. Bjorndal, and Alan B. Bolten</b> .....  | 100 |
| DIAGNOSIS OF HEMORRAHAGIC ENTERITIS AND HEPATITIS IN A SUBADULT LOGGERHEAD SEA TURTLE ( <i>CARETTA CARETTA</i> ) STRANDING IN ISLA ZAPARA, VENEZUELA   |     |
| <b>Libicni Rivero, Vanesa Ilukewitsch, Ninive Espinoza, Natalie Wildermann, Larry Bracho, Laura Carruyo, Robert Rincon, Hector A. Barrios-Garrido, and Maria G. Montiel-Villalobos</b> ..... | 101 |
| VITELLOGENIN PROFILE OF A MULTIPLE CLUTCH SEA TURTLE, <i>CARETTA CARETTA</i> , THROUGHOUT THE NESTING SEASON   |     |
| <b>Lauren E. Smith, Billie Poche', and Roldan Valverde</b> .....   | 101 |
| A GREAT AUSSIE DIVER: THE FLATBACK TURTLE*   |     |
| <b>Jannie B. Sperling, Gordon C. Grigg, and Colin J. Limpus</b> .....  | 102 |
| HEALTH ASSESSMENT OF NESTING LOGGERHEAD TURTLES ( <i>CARETTA CARETTA</i> ) IN WESTERN AUSTRALIA*   |     |
| <b>Sabrina Trocini, Peter Spencer, Stuart Bradley, Kristin Warren, Amanda O'Hara, Susan Perkins, and Ian Robertson</b> .....   | 103 |
| ESTABLISHING A PRE-RELEASE PROGRAM FOR THE GREEN SEA TURTLE ( <i>CHELONIA MYDAS</i> ) AT THE CAYMAN TURTLE FARM LTD., 1968: TRANSITIONING HATCHLINGS TO THE WILD                             |     |
| <b>Miriam C. Vadillo, Philip Admire, Bryan Andryszak, Marcus Williams, Ana Pinto, Chris Moersch, Ethan Manderson, and Erik Ebanks</b> .....  | 103 |
| PERSISTENT ORGANIC POLLUTANTS IN <i>CHELONIA MYDAS</i> EGGS: EVIDENCE OF MATERNAL TRANSFER, NESTING POPULATION VARIATION AND EFFECTS ON HATCHLING DEVELOPMENT*                               |     |
| <b>Jason van de Merwe, Shing Yip Lee, Joan Whittier, Kamarruddin Ibrahim, and Mary Hodge</b> .....   | 104 |

## **KEYNOTE ADDRESSES**

|  |     |
|--|-----|
| GREEN TURTLES IN THE WESTERN ATLANTIC AND CARIBBEAN: WHERE HAVE WE BEEN AND WHERE SHOULD WE GO?* |     |
| <b>Karen A. Bjorndal</b> .....   | 105 |
| CONSERVATION OF LEATHERBACKS ACROSS A CHANGING PLANET*   |     |
| <b>Peter Dutton</b> .....  | 105 |
| REDUCING SEA TURTLE MORTALITY FROM COASTAL FISHERIES: LESSONS FROM SOUTH CAROLINA*               |     |
| <b>Sally R. Hopkins-Murphy</b> .....   | 106 |
| LOGGERHEADS AND LEATHERBACKS IN THE WESTERN INDIAN OCEAN*  |     |
| <b>George R. Hughes</b> .....  | 107 |
| GREEN TURTLES IN AUSTRALASIA: LESSONS FROM 40 YEARS OF TURTLE MANAGEMENT?*                       |     |
| <b>Colin J. Limpus</b> .....   | 108 |
| HAWKSBILL TURTLES IN THE IOSEA REGION: A REVIEW OF MANAGEMENT EFFORTS*                           |     |
| <b>Jeanne A. Mortimer</b> .....  | 109 |
| FOUR DECADES OF PROGRESS. HOW ARE THE RIDLEYS DOING?*  |     |
| <b>Peter C. H. Pritchard</b> .....   | 110 |
| 40 YEARS OF SEA TURTLE CONSERVATION: WHAT WORKED? WHAT DIDN'T*                                   |     |
| <b>Perran Ross</b> .....   | 111 |

## **MIGRATION AND MOVEMENT**

|   |     |
|---|-----|
| SATELLITE-TRACKED MOVEMENTS OF LEATHERBACK SEA TURTLES, <i>DERMOCHELYS CORIACEA</i> , FROM SOUTHEASTERN BRAZIL<br><b>Antonio P. Almeida, Scott A. Eckert, Soraya C. Bruno, Juarez T. Scalfoni, Bruno Giffoni, and João Carlos A. Thomé</b> .....                    | 112 |
| USE OF THE GULF OF VENEZUELA WATERS BY FOREIGN SEA TURTLES: INFERENCES FROM 45 YEARS OF TAG RETURNS<br><b>Hector Barrios-Garrido and Ma. Gabriela Montiel-Villalobos</b> .....  | 113 |
| EPOXY USED IN SATELLITE TRANSMITTER ATTACHMENT: TOO HOT, TOO COLD, OR JUST RIGHT<br><b>Jen Beggs, Kristen Mazzarella, and Tony Tucker</b> .....   | 113 |
| TURTLE IDENTIFICATION FROM DIGITAL PHOTOGRAPHS: AN ARTIFICIAL INTELLIGENCE APPROACH<br><b>Ian P. Bell and Steven J.B. Carter</b> .....  | 114 |
| MOVEMENT OF SEA TURTLES BETWEEN NESTING SITES AND FEEDING GROUNDS IN THE SOUTH WEST INDIAN OCEAN: REGIONAL MIGRATORY KNOWLEDGE AND INTERACTION WITH OPEN SEA FISHERIES FOR MANAGEMENT ISSUES<br><b>Jérôme Bourjea and Stéphane Ciccione</b> .....                   | 114 |
| PHOTO-IDENTIFICATION OF MARINE TURTLES: AN ALTERNATIVE METHOD TO MARK-RECAPTURE STUDIES<br><b>Stéphane Ciccione, Claire Jean, and Jérôme Bourjea</b> .....  | 115 |
| MARINE TURTLE HATCHLING ORIENTATION: CONTRASTING MOVEMENTS OF DIAMONDBACK TERRAPINS AND SEA TURTLES<br><b>Andrew Coleman, Thane Wibbels, Ken Marion, David Nelson, and John Dindo</b> .....   | 115 |
| POST-NESTING MIGRATIONS OF HAWKSBILL TURTLES ( <i>ERETMOCHELYS IMBRICATA</i> ) IN THE STRAIT OF MALACCA*<br><b>Arvind Devadasan, Lau Min Min, and Grace S. Duraisingham</b> .....   | 116 |
| A TALE OF TWO BODY TYPES: STABILITY IN SWIMMING LOGGERHEAD ( <i>CARETTA CARETTA</i> ) AND GREEN ( <i>CHELONIA MYDAS</i> ) SEA TURTLE POSTHATCHLINGS*<br><b>Erin Dougherty, Gabriel Rivera, and Jeanette Wyneken</b> .....   | 116 |
| WHERE DO MEDITERRANEAN LOGGERHEADS STAY?<br><b>Silvia Galli, Resi Mencacci, Marco Affronte, Daniela Freggi, Riccardo Sirna, Paola Meschini, Dino Scaravelli, Paolo Casale, Silvano Benvenuti, and Paolo Luschi</b> .....  | 117 |
| MIGRATORY CONNECTIVITY AND CRITICAL CORRIDORS IN MEDITERRANEAN GREEN TURTLES*<br><b>Brendan Godley, Annette C. Broderick, Ali F. Canbolat, Onur Candan, Michael S. Coyne, Wayne J. Fuller, and Fiona Glen</b> .....   | 118 |
| GEOGRAPHIC DIFFERENCES IN MIGRATORY ACTIVITY BY HATCHLING LOGGERHEADS ( <i>CARETTA CARETTA</i> ): WHAT IS THE CAUSE?<br><b>Jeffrey Guertin, Cody Mott, Michael Salmon, and Tony Tucker</b> .....  | 118 |
| HORIZONTAL AND VERTICAL HABITAT UTILIZATION OF MIGRATING LEATHERBACK TURTLES IN THE NORTH PACIFIC: PRELIMINARY ANALYSIS WITH OCEANIC CURRENT DATA<br><b>Takashi Hosono, Hiroshi Minami, Makoto Okazaki, Hiroyuki Suganuma, Akil Yusuf, and Masashi Kiyota</b> ..... | 119 |
| MARINE TURTLE-FISHERIES INTERACTION MITIGATION TRAINING, DATA COLLECTON ACTIVITIES AND SATELLITE TELEMTRY IN THE REPUBLIC OF THE MARSHALL ISLANDS<br><b>Emma Kabua, Matylene Langidrik, Ketty Boktok, Denise Parker, and Karen Frutchey</b> .....                   | 120 |
| MEDITERRANEAN MIGRATIONS: ADULT MALE AND FEMALE LOGGERHEAD MOVEMENT BEYOND THE PROTECTED BREEDING AREA OF ZAKYNTHOS<br><b>Kostas A. Katselidis, Gail Schofield, Laurent Sourbes, and Amalia D. Karagouni</b> .....  | 121 |
| DETECTION OF BEACH-SPECIFIC MAGNETIC SIGNATURES BY SEA TURTLES: THE KEY TO NATAL HOMING?*   |     |
| <b>Kenneth J. Lohmann, Amy J. Horner, Leah Akins, and Catherine M. F. Lohmann</b> .....   | 121 |

|   |     |
|---|-----|
| RIO DE LA PLATA ESTUARY: A KEY FORAGING AREA FOR LEATHERBACKS IN THE<br>SOUTHWEST ATLANTIC<br><b>Milagros López-Mendilaharsu, Andrés Domingo, Philip Miller, Alejandro Fallabrino, Laura Prodocimi, and<br/>Carlos F. D. Rocha</b> .....  | 122 |
| SATELLITE TELEMETRY STUDIES IN BRAZIL HIGHLIGHT AN IMPORTANT FEEDING<br>GROUND FOR LOGGERHEADS AND HAWKSBILL: THE CEARÁ STATE COAST<br><b>Maria Â. Marcovaldi, Gustavo G. Lopez, Luciano S. Soares, Eduardo H.S.M. Lima, Paulo C.R. Barata, Soraya<br/>C. Bruno, and Antônio de P. Almeida</b> .....  | 123 |
| MONITORING THE ACOUSTIC ENVIRONMENT OF POST-NESTING LOGGERHEAD SEA<br>TURTLES ( <i>CARETTA CARETTA</i> )<br><b>Kelly J. Martin, David A. Mann, and Anton D. Tucker</b> .....  | 124 |
| REGIONAL MAGNETIC FIELDS AND ORIENTATION BY HATCHLING LOGGERHEADS FROM<br>FLORIDA'S WEST COAST<br><b>Maria W. Merrill, Michael Salmon, and Tony Tucker</b> .....  | 124 |
| MOVEMENT PATTERNS OF HAWKSBILL TURTLES ON THE CUBAN SHELF DESCRIBED BY<br>FLIPPER TAGGING AND SATELLITE TRACKING<br><b>Félix Moncada, Gonzalo Nodarse, Grahame J. W. Webb, Charlie Manolis, Yosvani Medina, and Erich<br/>Escobar</b> .....   | 125 |
| PALAU MARINE TURTLE MOVEMENTS: GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) FLIPPER TAG<br>RETURNS AND HAWKSBILL ( <i>ERETMOCHELYS IMBRICATA</i> ) SATELLITE TRACKING<br><b>Rachael Nash and Joshua Eberdong</b> .....  | 125 |
| NESTING BEACH USE PATTERNS OF LEATHERBACK TURTLES ( <i>DERMOCHELYS CORIACEA</i> )<br>IN BOCAS DEL TORO PROVINCE, PANAMA<br><b>Cristina Ordoñez, Carlos Fernandez, John Denham, Anne Meylan, Peter Meylan, and Emma Harrison</b> .....   | 126 |
| SWIMMING AND DISPERSAL BEHAVIORS OF 1-YEAR-OLD HEADSTARTED LOGGERHEADS<br>IN THE SOUTHEASTERN COAST OF SPAIN<br><b>Elena Abella Perez, Núria Plantalech Manel-la, Juan Patinho Martinez, and Adolfo Marco Llorente</b> .....  | 127 |
| EASTERN AUSTRALIAN MARINE TURTLE SATELLITE TRACKING PROJECT – FOLLOWING<br>INSHORE AND PELAGIC FORAGING SUB-ADULTS<br><b>Carolyn Robins and David Kreutz</b> .....  | 127 |
| NO TIME TO CHILL OUT: GPS TRACKING REVEALS MICRO-HABITAT SELECTION BY<br>BREEDING LOGGERHEAD TURTLES*<br><b>Gail Schofield, Charles M. Bishop, Kostas A. Katselidis, Panayotis Dimopoulos, John D. Pantis, and Graeme C.<br/>Hays</b> .....   | 128 |
| EXAMINATION OF SATELLITE TRANSMITTER ATTACHMENT TECHNIQUES FOR JUVENILE<br>SEA TURTLES<br><b>Erin E. Seney, Benjamin M. Higgins, and Andre M. Landry, Jr.</b> .....   | 129 |
| FINE SCALE MOVEMENT AND ACTIVITY PATTERNS OF EAST PACIFIC GREEN TURTLES AT<br>A COASTAL FORAGING AREA IN BAJA CALIFORNIA SUR, MEXICO<br><b>Jesse Senko, Volker Koch, William Megill, Ray Carthy, Robert Templeton, and Wallace J. Nichols</b> .....   | 130 |
| SATELLITE TRACKING REVEALS HIGH-USE HABITATS AND 3D THERMAL ENVIRONMENT<br>FOR INTERNESTING EASTERN PACIFIC LEATHERBACK TURTLES AT PLAYA GRANDE,<br>COSTA RICA*<br><b>George Shillinger, A. Swithenbank, Helen Bailey, S. Brogard, Daniel P. Palacios, Bryan Wallace, James Spotila,<br/>Frank Paladino, Rotney Piedra, and Barbara Block</b> ..... | 130 |
| SURFACING BEHAVIOR OF LOGGERHEAD TURTLES IN THE INTERNESTING PERIOD:<br>INSIGHTS FROM ANIMAL BORNE IMAGING SYSTEMS<br><b>Anton D. Tucker, Kyler J. Abernathy, and Greg J. Marshall</b> .....  | 131 |
| COMBINING OCEAN CURRENT MODELS AND TURTLE STRANDINGS DATA TO DETERMINE<br>THE AT-SEA DISTRIBUTION OF LOGGERHEAD TURTLES*<br><b>Chris Wilcox, Wayne Rochester, and Colin Limpus</b> .....  | 131 |

## **SOCIAL, ECONOMICAL, CULTURAL, AND LEGAL**

|  |     |
|--|-----|
| UPDATE ON THE COMMUNITY NETWORK FOR THE RECOVERY OF THE LEATHERBACK TURTLE IN MEXICO: WORKING TOGETHER FOR A COMMON CAUSE<br><b>Ana Rebeca Barragan and Laura Sarti</b> .....  | 132 |
| DEFINING KEY BIODIVERSITY AREAS IN MELANESIA FOR MARINE TURTLES<br><b>Deborah Bass and Paul Anderson</b> .....   | 132 |
| THE TURTLE VILLAGE TRUST, TRINIDAD AND TOBAGO, WEST INDIES: CONSERVATION AND MANAGEMENT OF SEA TURTLES THROUGH COMMUNITY COLLABORATION AND SUSTAINABLE DEVELOPMENT<br><b>Michelle Cazabon and Allan Bachan</b> .....   | 133 |
| ECONOMIC, SOCIAL, ENVIRONMENTAL, AND CULTURAL IMPACTS OF ACTIVITIES CENTERED AROUND SEA-TURTLES AT REUNION ISLAND<br><b>Stéphane Ciccione, Claire Jean, and Jerome Bourjea</b> .....   | 133 |
| REDUCING MORTALITY ON NESTING BEACHES IN CABO VERDE THROUGH STRUCTURED COLLABORATION WITH GOVERNMENT AND COMMUNITY<br><b>Jacque Cozens</b> .....   | 134 |
| TURTLE CONSERVATION IN NEW-CALEDONIA<br><b>Jean-Louis D'Auzon</b> .....  | 135 |
| THE OLIVE RIDLEY GOES BEYOND A FLAGSHIP SPECIES USED TO DERIVE SOCIAL AND ENVIRONMENTAL CHANGE IN CHENNAI<br><b>Supraja Dharini</b> .....  | 135 |
| EDUCATIONAL PROGRAM OF PROYECTO PEYU-PRICTMA<br><b>Jose Luis Di Paola and Cintia Echenique</b> .....   | 136 |
| SHARING DEVELOPING COUNTRY EXPERIENCE-AN INSIDE LOOK AT THE STRUGGLES IN SEA TURTLE RESEARCH AND CONSERVATION IN VENEZUELA*<br><b>Emma Doyle, Joaquín Buitrago, and Hedely J. Guada</b> .....  | 136 |
| REDEFINING SEA TURTLE STRANDING RESPONSE IN URUGUAY: CAPACITY BUILDING, AWARENESS CAMPAIGNS, COMMUNICATION AND NETWORKING – SOME NEW DIRECTIONS AND NOVEL APPROACHES<br><b>Andrés Estrades, Alejandro Fallabrino, Virginia Ferrando, Anand Ramanathan, and Eduardo Santurtun</b> ... | 137 |
| MARINE TURTLE RESEARCH AND CONSERVATION IN SOYO, NORTHERN ANGOLA<br><b>Betania Ferreira, Angela Formia, Antonio Nogueira, Warren Klein, Tim Bayhnam, and Howard Rosenbaum</b> .....  | 137 |
| ESTABLISHING A SOCIO-ECONOMIC BASELINE OF SEA TURTLE CONSERVATION TOURISM IN BAJA CALIFORNIA SUR, MEXICO*<br><b>Elena Finkbeiner, Brad Nahill, Larry Crowder, and Wallace J. Nichols</b> .....   | 138 |
| SCHIZOPHRENIC MARINE TURTLES? ENDANGERED OR PLAGUE SPECIES?*<br><b>Jack Frazier</b> .....  | 139 |
| EDUCATION, CONSERVATION AND RESEARCH ON SEA TURTLES IN FRENCH POLYNESIA: 3 MAIN GOALS DEVELOPED BY TE MANA O TE MOANA, A LOCAL NON-PROFIT FOUNDATION<br><b>Cécile Gaspar, Matthieu Petit, Nicolas Leclerc, and Vie Jourdan</b> .....   | 139 |
| ANATOMY OF A CONSERVATION SUCCESS STORY: LESSONS LEARNED FROM A HALF CENTURY OF COMMUNITY COLLABORATION, ECONOMIC INCENTIVE AND RESOURCE MANAGEMENT TACTICS AT TORTUGUERO, COSTA RICA*<br><b>David Godfrey and Emma Harrison</b> .....   | 140 |
| THE INITIAL RESULTS FROM THE COMMUNITY BASED SEA TURTLE CONSERVATION PROGRAM AT BAI TU LONG AREA AND LESSONS FOR FUTURE ACTIVITIES<br><b>Pham Tuan Hung, Bui Thi Thu Hien, and Chu The Cuong</b> .....   | 140 |
| THE IOSEA ONLINE REPORTING FACILITY: A CUTTING-EDGE TOOL FOR TURTLE PRACTITIONERS AND DECISION-MAKERS*<br><b>Douglas Hykle</b> .....   | 141 |
| COMPLIANCE AND ENFORCEMENT IN SEA TURTLE CONSERVATION IN FIJI*<br><b>Joytishna Jit</b> .....   | 141 |

|  |     |
|--|-----|
| “SEA TURTLE 101”: EDUCATING AND ENGAGING A LOCAL COMMUNITY THROUGH AN IN-WATER SEA TURTLE RESEARCH PROJECT AT JOHN BREWER’S BAY, ST. THOMAS, U.S. VIRGIN ISLANDS     |     |
| <b>Kemit-Amon Lewis and Paul Jobsis</b> .....  | 142 |
| EFFECTIVENESS OF CONSERVATION MEASURES FOR SEA TURTLE MANAGEMENT: THE EXAMPLE OF ITSAMIA, MOHELI - COMOROS UNION   |     |
| <b>Anfan M’soili, Cyril Marmoeux, Marie Lauret-Stepler, Francois Beudard, Stéphane Ciccione, and Jérôme Bourjea</b> .....  | 143 |
| IMPLEMENTING INTERNATIONAL INSTRUMENTS IN MANAGEMENT OF SEA TURTLES OF THE WESTERN INDIAN OCEAN REGION*  |     |
| <b>Jane R. Mbendo</b> .....  | 143 |
| RE-ESTABLISHING SEA TURTLE CONSERVATION EFFORTS IN PULAU BANYAK, ACEH, SUMATRA, INDONESIA  |     |
| <b>Maggie Muurmans and Mahmud Bangkaru</b> .....   | 144 |
| THE GEORGIA SEA TURTLE CENTER, 1 YEAR LATER  |     |
| <b>Stefanie A. Ouellette, Terry M. Norton, William P. Irwin, Michelle Kaylor, Erika Kemler, Alicia Marin, Sarah Mathias, Jeannie Miller, and Kelly O’Keefe</b> ..... | 144 |
| A NATIONAL COMMUNITY-BASED SEA TURTLE CONSERVATION PROGRAMME IN VANUATU  |     |
| <b>George Petro</b> .....  | 145 |
| RECOVERY, DE-LISTING, AND THE BEST AVAILABLE SCIENCE DEBATE IN SEA TURTLE CONSERVATION*  |     |
| <b>Alison Rieser</b> .....   | 146 |
| PROTECTING NESTING LOGGERHEADS ON BOA VISTA, CAPE VERDE USING MILITARY PRESENCE  |     |
| <b>Christian Roder</b> .....   | 146 |
| DHAMRA PORT: HOW ENVIRONMENTAL REGULATORY FAILURE FUELS CORPORATE IRREVERENCE*   |     |
| <b>Sudarshan Rodriguez and Aarthi Sridhar</b> .....  | 147 |
| CHILDREN, MARINE TURTLES AND MAIL FOR A COMMON OBJECTIVE: RESCUING THE HAND WRITTEN LETTER AND NATURAL RESOURCES   |     |
| <b>G. Tiburcio Pintos, J. Alcantar-Armenta, S. Carter , Estrella, A. Barrios, M. Arrecis , and S. Sankaran</b> .....   | 147 |
| MARINE CHELONIAN ILLUSTRATION-PART SEVEN: SEA TURTLES – IN A LINNEAN STATE OF MIND   |     |
| <b>Chuck Schaffer and Rick Schaffer</b> .....  | 148 |
| A FLAGSHIP, A PORT AND A UNION - CONSERVATIONS AND CORPORATIONS: COLD WAR OR COMMON CAUSE?*  |     |
| <b>Kartik Shanker</b> .....  | 149 |
| COASTAL REGULATIONS AND TURTLE CONSERVATION IN INDIA – IMPLICATIONS OF ONGOING REFORMS   |     |
| <b>Aarthi Sridhar, Manju Menon, Sudarshan Rodriguez, and Seema Shenoy</b> .....  | 149 |
| STATE OF <i>CHELONIA MYDAS</i> (GREEN TURTLE) IN FRENCH POLYNESIA CONTRIBUTION OF NGO TE HONU TEA TO ITS STUDY AND PROTECTION  |     |
| <b>Alexandre Tayalé and Sophie Gaugne</b> .....  | 150 |
| DEVELOPING A SEA TURTLE RESEARCH NETWORK IN THE SOUTH ATLANTIC   |     |
| <b>Manjula Tiwari and Alan B. Bolten</b> .....   | 151 |
| PROTUMAR: 6 YEARS OF COMMUNITY PARTICIPATION ON SEA TURTLE CONSERVATION IN THE COAST OF OAXACA, MEXICO   |     |
| <b>Floriberto Vásquez Ruiz, Agustín Reyes Sánchez, and Ana Barragan Rocha</b> .....  | 151 |
| BUILDING BRIDGES: SEA TURTLE CAPACITY BUILDING AND ENVIRONMENTAL EDUCATION OUTREACH, PATOK ALBANIA   |     |
| <b>Michael White, Idriz Haxhiu, Enerit Saçdanaku, Lazion Petritaj, Merita Rumano, Lily Venizelos, Stephanos Kouris , and Prue Robinson</b> .....                     | 152 |
| A FIRST EVALUATION OF THE KNOWLEDGE AND USES OF SEA TURTLES IN COASTAL COMMUNITIES OF SINALOA’S NORTH, GULF OF CALIFORNIA, MEXICO                                    |     |
| <b>Alan A. Zavala, Raquel Briseño, Mario Ramos, and A. Alonso Aguirre</b> .....  | 152 |

## **SPEED SESSION 1**

|  |     |
|--|-----|
| GREEN TURTLES IN THE EPARSE ISLANDS, SW INDIAN OCEAN: MITIGATED POPULATION STATUS BASED ON A 25 YEAR TREND OF DAILY TRACK COUNTS<br><b>Jérôme Bourjea, Cyril Marmoeux, Marie Lauret-Stepler, Francois Beudard, and Stéphane Ciccione</b> ..... | 153 |
| INTER-ANNUAL VARIATION IN MAGNITUDE OF BREEDING MAY MASK CLIMATE CHANGE IMPACTS IN MARINE TURTLES<br><b>Annette C. Broderick, Wayne J. Fuller, Brendan J. Godley, and Matthew J. Witt</b> .....  | 154 |
| TO EAT OR NOT TO EAT: SEA TURTLE CONSUMPTION IN THE BRITISH OVERSEAS TERRITORIES IN THE CARIBBEAN<br><b>Lisa M. Campbell and Sue Ranger</b> .....  | 154 |
| CONTEXT FOR MANAGING INDIGENOUS HUNTING IN AUSTRALIA<br><b>Kirstin Dobbs and Donna Kwan</b> .....  | 154 |
| RAINE ISLAND: ISSUES AND IMPLICATIONS<br><b>Mark Hamann and Mariana Fuentes</b> .....  | 155 |
| REASSESSMENT OF THE HISTORICAL DISTRIBUTION OF GREEN TURTLE HUNTING BY PAPUA NEW GUINEAN KIWAI HUNTERS IN TORRES STRAIT<br><b>Lauren Hess, Mark Hamann, Donna Kwan, and Jillian Grayson</b> .....  | 156 |
| SURVEY TO DETERMINE INCIDENCES OF HUMAN FATALITY & ILLNESS FROM TURTLE MEAT CONSUMPTION IN THE UNITED REPUBLIC OF TANZANIA<br><b>Catharine Joynson-Hicks and John Mbugani</b> .....  | 156 |
| CONSUMPTION OF MARINE TURTLES IN FIJI AND IMPACT ON HAWKSBILL AND GREEN TURTLE STOCKS IN THE WESTERN PACIFIC<br><b>Kenneth MacKay, Merewalesi Laviti, and Neema Nand</b> .....   | 157 |
| THE ROLE OF EXTERNAL CALCIUM CARBONATE IN LOGGERHEAD TURTLE NEST INCUBATION<br><b>Mario J. Mota and Ray R. Carthy</b> .....  | 157 |
| COMPARING NESTING STRATEGIES OF LOGGERHEAD AND LEATHERBACK TURTLES IN SA: DOES EQUAL CONSERVATION EFFORT MEAN EQUAL RECOVERY POTENTIAL?<br><b>Ronel Nel</b> .....  | 158 |
| TRACKS COUNTS: A USEFUL TOOL FOR MONITORING TEMPORAL AND SPATIAL TRENDS IN SEA TURTLE NESTING ACTIVITY AND POTENTIAL IMPACTS FROM INDUSTRY<br><b>Jessica Oates, Kellie Pendoley, and Milani Chaloupka</b> .....                                | 159 |
| ANNUAL SURVIVAL OF NESTING LOGGERHEADS IN THE NORTHWEST ATLANTIC OCEAN<br><b>Christopher R. Sasso, Llewellyn Ehrhart, Michael Frick, William Redfoot, Kristina Williams, and Julio Zurita</b> .....  | 160 |

## **SPEED SESSION 2**

|  |     |
|--|-----|
| POPULATION STRUCTURE AND USE OF A NEWLY IDENTIFIED FORAGING GROUND IN THE SOUTH CARIBBEAN COAST OF COSTA RICA<br><b>Joana M. Hancock and Didier Chacon</b> .....   | 160 |
| COMMUNITY CONSERVATION: A NOVEL APPROACH IN THE SRI LANKAN SEA TURTLE CONSERVATION SCENARIO<br><b>Thushan Kapurusinghe, Lalith Ekanayake, Saman Rathnakumara, M.M. Saman, and Anand Ramanathan</b> ..... | 161 |
| HORIZONTAL TRANSFER TO CHANGE FISHERS' CULTURES AND ATTITUDES ON TURTLE BYCATCH - THOUGHTS AND OPINIONS OF A COMMERCIAL FISHER<br><b>David Kreutz</b> .....  | 162 |
| THE USE OF COMMUNITY "CONSERVATION DEEDS" AS A TOOL TO MANAGE MARINE CONSERVATION AREAS<br><b>Wenceslaus Magun</b> .....   | 162 |
| TURTLE DEATHS AT SEA UNDERMINE PROTECTION MEASURES ON NESTING AREAS IN WESTERN PELOPONNESUS AND ZAKYNTHOS, GREECE<br><b>Aliki Panagopoulou, Paul Tsaros, and Dimitris Margaritoulis</b> .....            | 163 |

|   |     |
|---|-----|
| THE USE OF DEVELOPMENT INCENTIVES TO PROMOTE BUY-IN AMONGST LOCAL COMMUNITIES FOR TURTLE CONSERVATION IN PAPUA NEW GUINEA<br><b>Nicolas J. Pilcher and Irene Kinan Kelly</b> .....  | 164 |
| THE MANAGEMENT OF MARINE TURTLES WITHIN THE GREAT BARRIER REEF MARINE PARK<br><b>Mark Read and Malcolm Turner</b> .....   | 164 |
| LONG-TERM TRENDS IN BASKING HAWAIIAN GREEN SEA TURTLES IN THE NORTHWESTERN HAWAIIAN ISLANDS<br><b>Melissa L. Snover and Mark S. Sullivan</b> .....  | 165 |
| THE INTRODUCTION OF TURTLE EXCLUDER DEVICES IN SHRIMP TRAWL NETS AND SEA TURTLE CONSERVATION STRATEGIES IN SMALL SCALE FISHERIES IN THE SOUTHERN GULF OF GUINEA<br><b>Bolu Solarin, T. Moth-Poulsen, V. Amire, J. C. Ogbonna, E. E. Ambrose, O. Bolaji, O. Orimogunje, M. Abass, O. Adegbile, A. Ajulo, F. Aniebona, and S. C. Oporum</b> ..... | 165 |
| PATOKU: MONITORING AN IMPORTANT SEA TURTLE FORAGING GROUND IN ALBANIA<br><b>Michael White, Idriz Haxhiu, Enerit Saçdanaku, Lazion Petritaj, Merita Rumano, Prue Robinson, Stephanos Kouris, and Lily Venizelos</b> .....  | 166 |
| SEA TURTLE CONSERVATION IN BALI – INDONESIA, SOCIAL – CULTURAL, EDUCATION, PRESS AND LAW ENFORCEMENT APPROACH<br><b>I Wayan Wiradnyana</b> .....  | 167 |
| SAVING THE MARINE TURTLES - THE MEKAR EXPERIENCE<br><b>Rahayu Zulkifli and Rejani Kunjappan</b> .....   | 167 |

### **SPEED SESSION 3**

|   |     |
|---|-----|
| FORAGING DESTINATIONS AND HIGH-USE AREAS OF WESTERN PACIFIC LEATHERBACK TURTLES<br><b>Scott Benson, Peter H. Dutton, Creusa Hitipeuw, Betuel Samber, Ricardo Tapilatu, Vagi Rei, Levi Ambio, John Pita, Peter Ramohia, Joe Horoku, Tomo Eguchi, and Barbara Block</b> ..... | 168 |
| OXYGEN CONSUMPTION AND SWIMMING EFFORT OF HATCHLING GREEN TURTLES<br><b>David T. Booth</b> .....  | 169 |
| RECONSTRUCTION OF HISTORIC SEA TURTLE POPULATIONS AROUND MAURITIUS AND IDENTIFICATION OF APPROPRIATE CONSERVATION GOALS FOR A GHOST POPULATION<br><b>Patricia Z. R. Davis and Noa Sainz</b> .....   | 169 |
| ‘SHARED SEAS’: MARINE TURTLES IN THE ARAFURA-TIMOR SEAS<br><b>Kiki Dethmers, Ray Chatto, Narciso A. de Carvalho, and Karren Edyvane</b> .....   | 170 |
| CAN <i>CASUARINA</i> AS SHELTERBELTS SPELL DOOM FOR THE <i>LEPIDOCHELYS OLIVACEA</i> NESTING ALONG SOUTHERN CHENNAI COAST IN INDIA?<br><b>Supraja Dharini</b> .....   | 170 |
| USE OF MICROSATELLITE MARKERS FOR EVALUATING THE RELATEDNESS AMONG GREEN TURTLE NESTS FOUND ON THE MAIN HAWAIIAN ISLANDS<br><b>Amy Frey, Peter H. Dutton, and George H. Balazs</b> .....  | 171 |
| SEARCHING FOR THE BEST HISTORICAL RECORD IN THE CARAPACE OF GREEN TURTLES<br><b>Melania C. López-Castro, Karen A. Bjorndal, and Alan B. Bolten</b> .....  | 171 |
| SOCIAL AND ECONOMIC FACTORS DRIVING ILLEGAL SEA TURTLE FISHERY AND TRADE IN BCS, MEXICO<br><b>Agnese Mancini, Ricardo Borquez Reyes, Volker Koch, and Jeff Seminoff</b> .....   | 172 |
| DISPERSAL PATTERNS AND SWIMMING BEHAVIOUR OF HATCHLING FLATBACK TURTLES ( <i>NATATOR DEPRESSUS</i> )<br><b>Andrea D. Phillott</b> .....   | 172 |
| EYES IN THE SKY: DEFINING A LOGGERHEAD FORAGING HOTSPOT IN THE EASTERN PACIFIC THROUGH AERIAL SURVEYS<br><b>Jeffrey A. Seminoff, Tomoharu Eguchi, S. Hoyt Peckham, Rodrigo Rangel, and Karin Forney</b> .....   | 173 |
| THE INFLUENCE OF THE WORLD BANK ALONG INDIA'S COASTAL HABITATS<br><b>Seema Shenoy, Tanvi Vaidyanathan, Manju Menon, and Aarthi Sridhar</b> .....  | 173 |

|   |     |
|---|-----|
| DEVELOPMENT OF REGIONAL MANAGEMENT UNITS FOR SEA TURTLES: APPLICATIONS FOR THREATS EVALUATION, GAP ANALYSES, DIVERSITY HOTSPOTS ASSESSMENT, AND CONSERVATION PRIORITY SETTING<br><b>Bryan Wallace, Elena Finkbeiner, and S'rai Helmbrecht</b> ..... | 174 |
|---|-----|

**TURTLE USE / SUSTAINABLE USE**

|   |     |
|---|-----|
| ASSESSING THE ECONOMIC VALUE OF SEA TURTLE HUNTING TO INFORM SEA RESOURCE MANAGEMENT POLICY IN THE TORRES STRAIT, AUSTRALIA*<br><b>Aurelie Delisle</b> .....  | 175 |
| CULTURAL ANTHROPOLOGY OF TASTE IN PEARL LAGOON: SOCIAL AND ECONOMIC FACTORS DRIVING GREEN TURTLE CONSUMPTION IN CARIBBEAN NICARAGUA<br><b>Katy Garland, Ray Carthy, Charles Wood, Lance Gravlee, Cathi Campbell, Susan Jacobson, and Perran Ross</b> .....  | 175 |
| A TOOLBOX OF TOOLS FOR MANAGING THE TORRES STRAIT GREEN TURTLE FISHERY*<br><b>Jillian Grayson, Mark Hamann, Helene Marsh, and Stephen Ambar</b> .....   | 176 |
| DO TOURIST ACTIVITIES AFFECT GREEN TURTLE ( <i>CHELONIA MYDAS</i> ) NESTING BEHAVIOUR AND HATCHING SUCCESS AT TORTUGUERO, COSTA RICA?<br><b>Emma Harrison, Xavier Debade, Dagnia Nolasco, Catalina Gonzales, and Luis González</b> .....                    | 177 |
| PROGRESS TOWARDS A SUSTAINABLE GREEN TURTLE FISHERY ON THE CARIBBEAN COAST OF NICARAGUA*<br><b>Cynthia J. Lagueux, Rodolfo Chang, and Cathi L. Campbell</b> .....   | 177 |
| MARINE TURTLE CONSUMPTION AND TURTLE SHELL TRADING AS MAJOR THREATS TO FIJI'S TURTLE POPULATIONS: A CASE STUDY IN THE MAMANUCA ARCHIPELAGO AND MUNICIPAL MARKETS AROUND VITILEVU, FIJI*<br><b>Merewalesi Laveti, Kenneth MacKay, and Fesi Isimeli</b> ..... | 178 |
| TORRES STRAIT MARINE TURTLE AND DUGONG PROJECT – COMMUNITY-BASED MANAGEMENT AND PLANNING*<br><b>Frank Loban and Lachlan Sutherland</b> .....  | 179 |
| TOURISTS AND TURTLES: SEARCHING FOR A BALANCE IN TORTUGUERO, COSTA RICA*<br><b>Zoe A. Meletis and Emma Harrison</b> .....   | 179 |
| MALAMA NA HONU: PERCEPTIONS OF VOLUNTEERS AT LANIAKEA BEACH, OAHU, HAWAII<br><b>Robert H. Schmidt</b> .....   | 180 |
| COMBINING INDIGENOUS AND SCIENTIFIC KNOWLEDGE TO MANAGE MIGRATORY MARINE SPECIES ACROSS SCALES: CHALLENGES AND OPPORTUNITIES*<br><b>Kristen C. Weiss</b> .....  | 180 |
| <b><u>Author Index</u></b> .....  | 182 |

## **AUSTRALIA MINI-SYMPOSIUM**

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### **DO MANAGEMENT PLANS OR TRADITIONAL USE AND CONSERVATION AGREEMENTS REALLY CHANGE HOW MANY TURTLES ARE TAKEN BY INDIGENOUS COMMUNITIES? WORKING TOWARDS DEVELOPING REAL SUSTAINABLE TURTLE HUNTING PRACTICES IN NORTH QUEENSLAND\***

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North Queensland Aboriginal people and Torres Strait Islanders have historically taken marine turtles and their eggs as both a valuable source of protein and for traditional purposes over many generations. Today, however, modern technologies such as high speed boats now allow access to areas that were never or rarely visited, and provide an ability to take turtles and eggs at an increased quantity and frequency. This hunting effort has led to a localised paucity of turtles in coastal areas adjacent to some communities. The targeted hunting of adult female turtles in their feeding areas is also likely to be a contributing factor in the decline of green turtles, *Chelonia mydas*, nesting in the far northern section of the Great Barrier Reef World Heritage Area. Management agencies recognise this and are attempting to put in place strategies that address these issues such as: conducting workshops with Traditional Owner groups and other Government agencies; developing consultation strategies to engage Traditional Owner groups in the management agencies programs; creating culturally appropriate policies that reflect Traditional Owner's cultural and heritage values for their sea country; distributing posters, newsletters, fact sheets and website information which provide cultural awareness of Aboriginal and Torres Strait Islander peoples relationships and connection to sea country; and encouraging Aboriginal and Torres Strait Islander membership on various management boards and consultative committees. The value of laying a foundation of collaborative co-management is recognised. However, these strategies have typically failed to address the fundamental need of engaging actual hunters in the development of on-ground activities that specifically address sustainable management techniques for their coastal and sea country. In this paper I will discuss successes and failures of hunter involvement in the north Queensland marine turtle research program with examples from two Traditional Owner groups.

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### **MAKING TURTLES COUNT ON THE NSW NORTH COAST\***

**Marny Bonner, Keith Williams, and Rochelle Ferris**

Australian Sea Bird Rescue, Alstonville, NSW, Australia

Six species of marine turtles occur in Australian waters. The NSW North Coast is the southernmost limit of the breeding and nesting areas for three species: *Caretta caretta*, *Chelonia mydas* and *Dermochelys coriacea*. An additional three species have also been sighted in local waters: *Eretmochelys imbricata*, *Lepidochelys olivacea* and *Natator depressus*. However, most research has been focused on populations that occur in the northern states such as Queensland and the Northern Territory. There is a lack of data regarding turtle populations on the northern New South Wales coastline. Some theories state that there is an increase in sightings of turtles in NSW despite the significant decline in populations worldwide. Australian Seabird Rescue (ASR) is undertaking the "Make Turtles Count" project, with funding from the WWF Threatened Species Network and support from NSW National Parks and Wildlife Service, Cape Byron Marine Park and Southern Cross University. The project will seek to activate and inform a large number of volunteer participants to undertake daily patrols of nesting beaches in the region during breeding season (November 2008 to April 2009), enabling ASR to collate and publish the nesting data for ongoing management strategies and community awareness activities. In addition, the project will undertake population surveys of coastal reefs and adjacent

areas on a quarterly basis in the Northern Rivers Region of NSW. This will allow population comparisons during both breeding and non-breeding seasons.

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## **DRAFT MARINE TURTLE RECOVERY PLAN FOR WESTERN AUSTRALIA\***

**Tamra F. Chapman, Alan Kendrick, Keith Morris, Fran Stanley, and Marissa Speirs**

Department of Environment and Conservation, Western Australia

Five of the world's seven recognised species of marine turtle are known to breed on the coast and islands of northern Western Australia: the flatback (*Natator depressus*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and loggerhead (*Caretta caretta*) turtles. The leatherback (*Dermochelys coriacea*) also forages in (and migrates through) Western Australian waters. Most of the marine turtles that nest in Western Australia represent distinct genetic stocks and are significant for global marine turtle conservation because their breeding populations are estimated to be among the largest and most important in the Indo-Pacific region. In the past, marine turtles have been exploited and killed en masse in Western Australia. For example, green turtle populations were subject to major impacts such as atomic testing in the Montebello Islands in the 1950s and commercial harvesting for export and trade of meat and shell from the 1930s until 1973. The genetic stocks of marine turtles that currently nest in Western Australia are subject to a range of threats, including industrial (particularly oil and gas) and coastal development, predation by foxes and dogs, recreation and tourism, fishing bycatch, indigenous and illegal hunting, marine debris entanglement, pollution and spills and, more recently, climate and sea level change. In 2008, the Department of Environment and Conservation produced a Draft Marine Turtle Recovery Plan for Western Australia. The draft recovery plan addresses actions required to stop the further decline of marine turtle populations and to facilitate their recovery throughout their range in Western Australia. The Department faces significant challenges to meet these objectives, particularly in regard to minimising the threats posed by resource extraction and associated coastal development. Approximately 71% of Australia's oil and 56% of Australia's gas is produced in northwest Western Australia and the associated resource basins closely coincide with important turtle rookeries and feeding sites. However, the Department has a number of tools and mechanisms in place to facilitate the recovery and management of marine turtles in Western Australia. These include an established tagging program that has provided 21 years of data on breeding biology, carefully managed tourism and recreation in high use areas, introduced predator monitoring and control for selected beaches, fishing bycatch monitoring and minimisation (by the Department of Fisheries Western Australia) and a growing number of research programs. With the co-operation of the resource industry, the Commonwealth Government, other State government departments, local government, non-government organisations, universities and the tourism and recreation industry, the Department hopes to better understand and minimise threats to marine turtle populations in Western Australia and make a contribution to local and global marine turtle conservation.

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## **A SURVEY PROGRAM TO LOCATE AND DOCUMENT THE DISTRIBUTION AND STATUS OF MARINE TURTLE NESTING AROUND THE COASTLINE OF THE NORTHERN TERRITORY OF AUSTRALIA\***

**Ray Chatto**

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The Northern Territory (NT) of Australia has 10,000+ km of coast, 800+ islands and huge areas of near-coastal wetlands. The majority of this vast area is very remote, inaccessible and still largely undisturbed. Prior to 1990 there had been few systematic or comprehensive attempts to inventory the biodiversity of most of this area. From 1990 to 2004 (and incidentally thereafter) I conducted extensive aerial and ground surveys of this area. These surveys focused on locating and documenting significant sites for a variety of fauna species, including aquatic birds, marine reptiles and marine mammals. Over 70,000 records were collected during more than 500 field days of surveying. Numerous important, previously undocumented sites were located for each of these different species groups. Many of these sites can be regarded as nationally or internationally significant based on numbers of animals present. The results of these surveys have been documented in a series of five detailed Technical Reports which can be found on the NT's NRETA

government website address (<http://www.nt.gov.au/nreta/publications/wildlife/science>). Over 7,000 records relating to marine turtle nesting were recorded around the NT coast during the survey period. Marine turtles were recorded nesting around much of the mainland coast and on many of the islands with sandy beaches. Most of the high density areas were located on offshore islands where egg predation was lower. Four species of sea turtles (flatback (*Natator depressus*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*) turtles) were regularly recorded nesting. Few leatherback (*Dermochelys coriacea*) and no loggerhead turtles (*Caretta caretta*) were recorded nesting. Flatback turtles were recorded as the most widespread nesting species. They nested on nearly all beaches where some marine turtle nesting occurred. Olive ridley turtles were the second most widespread nesting species, followed by greens then hawksbills. Flatback and green turtles were the two most abundant nesting species, followed by olive ridleys and hawksbills. Although green turtle nesting was less widespread than flatback nesting, it was usually at much higher densities. Nesting was documented during every month throughout the year, but the majority of nesting for each of the four main species was seasonal. Flatbacks and olive ridleys mostly nested from April to September, through the dry season, while greens and hawksbills primarily nested in the later half of the year. There was also a small amount of seasonal variation with latitude along the eastern coast. As with the many other important fauna sites around the NT coast, the significant marine turtle nesting sites are still not subject to the pressures associated with large human populations, as is the case on much of the Australian coast. As such, we should now assume a proactive approach (including setting up long term monitoring programs) to guarantee the future security of these important sites before problems arise, rather than having to seek reactive remedies after it may be too late.

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## **THE EFFECT OF INCUBATION TEMPERATURE ON MORPHOLOGY AND RUNNING PERFORMANCE OF LOGGERHEAD SEA TURTLE HATCHLINGS FROM MON REPOS, AUSTRALIA**

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Incubation temperature is known to influence sea turtle incubation duration, hatchling sex, and possibly hatchling fitness. However, information on the impact of incubation temperature to the locomotor performance of loggerhead hatchlings within the first few hours after hatching is still limited. Sand and nest temperatures from four groups of loggerhead turtle (*Caretta caretta*) nests at Mon Repos rookery (Australia) were monitored over two breeding seasons. They included two groups (25 clutches) during 2005-2006 and two groups (20 clutches) during 2006-2007. Twenty hatchlings from each of 28 clutches were weighed and measured and then run in the speed trials. The incubation temperatures of sampled nests at Mon Repos rookery in the 2005-2006 nesting season ranged from 30°C to 33°C, above the pivotal temperature of this nesting population. Hatchling masses and dimensions were similar between the two nesting seasons and were positively correlated with initial egg mass and egg diameter. In addition, hatchling mass and dimensions were also weakly influenced by incubation temperature. Hatchlings from warmer nests were smaller in weights and measurements than hatchlings from cooler nests. The running speed of hatchlings averaged about 0.07 m/s and was affected by hatchling size and incubation temperature. Hence it is concluded that both clutch origin and incubation temperature affect the locomotor performance of loggerhead turtle hatchlings. On the other hand, the variation in amplitude of daily cyclic nest temperature fluctuations did not affect size and running speed of hatchlings.

## **DIET AND FEEDING BIOLOGY OF ADULT OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) AND LOGGERHEAD (*CARETTA CARETTA*) SEA TURTLES IN FOG BAY, NORTHERN TERRITORY, AUSTRALIA**

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A shark-fin fishery by-catch incident in Fog Bay, Northern Territory killed more than 300 sea turtles (four species) over a two-week time period in 1991. Approximately 100 stranded carcasses were necropsied on the beach. The stomach contents of 36 olive ridley and 3 loggerhead sea turtles were identified. The gastropods *Turritella terebra* and *Nassarius crematus* were the most commonly found prey items. Both species of sea turtle selected *T. terebra* as the target species with almost complete niche overlap. A benthic survey of Fog Bay established likely feeding zones based on similarities between dietary and field data. Further support for identifying the feeding locations came from a model comparing the reconstructed crushed shells of *T. terebra* from the stomachs with length-frequency and biomass data for this species from field sites. Speculation of metabolism and feeding dynamics for these species are provided. A model based on energy requirements from the literature, reconstructed stomach contents, and gastropod biomass from field data suggested the average olive ridley digestive tract contained 166.2 Kcal. and that of the average loggerhead contained 201.1 Kcal with a turnover rate of 1.5 and 1.8 days respectively. Based on this model, a volume of 2.6 m<sup>3</sup> of feeding ground would be needed for each individual to get their daily calorific requirements.

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## **TUDU TURTLE FORAGING POPULATION MONITORING, WAPA AND TIDIU MAZA (WARRIOR AND DUNGENESS REEF)\***

**Charles David<sup>1</sup>, Frank Loban<sup>2</sup>, and Mark Hamann<sup>3</sup>**

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Koeyma esso mura nitamun buais lagau kulka Iama malu warual dungalal mabaigal zagetau lagaugal. Ngalmun ka kuik iam ka nalmun jaget, koeyma esso (Thank you to the original people and rightful owners of the waters of Magan, the Kulkalgal of Iama, Gebar and Tudu, for permitting our marine turtle research and monitoring project). The Iama sea country is part of what is called the Magani Malu (sea country around the islands of Iama, Poruma, Warraber and Masig) within the Kulkalgal Nation (cultural group of central Torres Strait). This includes numerous islands and reefs varying in size, with beaches that provide nesting and foraging environment for unuwa waru (hawksbill turtles), waru (green turtles) and lugered (loggerhead turtles). The Tudu Marine Turtle Foraging Population Survey is a part of the Torres Strait Marine Turtle and Dugong Management Project, coordinated by the TSRA. The foraging turtle population survey was undertaken from Tudu Island during July 2008 and included turtle rodeo work along Wapa maza (Warrior Reef) and Tidiu maza (Dungeness Reef). Charles David, a Kulkalaig (person of Kulkalgal) from Iama was assisted by four Kulkalaig from Iama community to coordinate the project. Kulkalgal hosted project officers and rangers from Malu Kiai (Boigu), Besi (Mabuiag), Kirriri (Hammond), Muralag (Prince of Wales), and Wugalgal on Moa Island. Dr. Mark Hamann from JCU provided training and supervision to the survey. The project activities took place over a week and included catching, tagging and measuring turtles, attaining genetic samples for DNA analysis of the Wapa and Tidiu turtle population, and performing laparoscopic operations on turtles 40 cm or less (warkuz/mergarr) to determine their sex and health status. Traditional and contemporary science integrated smoothly during the week at Tudu. One of the primary achievements of conducting the Tudu Tagging Project was community empowerment. This is the first time the Amalgam (people from Iama) has participated in such a project, especially with a culturally significant species such as the marine turtle. A large number of hawksbill, green and loggerhead turtles were caught during the week-long survey. One tag return was documented from a loggerhead tagged at Bundaberg in 2006. A number of traditional

owners were trained in contemporary monitoring methods and skills were transferred between researchers and traditional owners. The results of the survey provide a starting point for the lama community to monitor their significant marine turtle resources. Kulkalaig wish to continue this work, contribute to their overall understanding of marine turtles in their sea country and work with researchers to sustainably manage their populations.

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## **ESTIMATING NESTING SUCCESS AT A HIGH-DENSITY GREEN TURTLE ROOKERY ON RAINE ISLAND, QUEENSLAND, USING DISTANCE SAMPLING AND LINE TRANSECTS\***

**Nancy F. FitzSimmons<sup>1</sup>, Anton D. Tucker<sup>2</sup>, Duncan J. Limpus<sup>3</sup>, and Colin J. Limpus<sup>4</sup>**

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Raine Island in the northern Great Barrier Reef supports one of the world's largest green turtle rookeries. Although the island is a remote and protected nature reserve, there is evidence suggesting that this rookery shows early signs of population decline. Two areas of concern include the level of harvest this population experiences and an apparently low hatchling production. Several factors are thought to contribute to reduced hatchling numbers, including the proportion of females successfully laying eggs, nest disturbance by other turtles and flooding from high tides and storm surges or after rains that raise the water table and impact nests in depressed areas. Although nesting density can be quite high, with thousands of turtles ashore, many females do not successfully nest. A range in nesting success of 14-73% has been reported, and these values reflect a negative correlation between nesting success and turtle density. These data have been based on the nesting success of turtles within 100 m wide sectors of the beach that are monitored throughout the night at (typically) two locations, 1 - 2 times during a season (since 1981). Due to variation in the estimates of nesting success within the quadrats, we decided to employ line transect methods that would account for the variation in nesting success observed around the island. For each of three years, 30 transect lines were established on the island, extending from the high tide line, inwards towards the edge of the available nesting area. Transect lines were walked around the island throughout the evening (8-9 nights per year). To estimate egg laying success, a distance sampling method was used along the transect lines. All turtles that were visible from the transect line, while using an LED intensity head torch, were assessed to see if they were laying eggs. For egg-laying turtles, their distance to the transect line was measured to within 1 m accuracy. In using a distance sampling approach, it is expected that sighting success will drop off with increased distance from the transect line. This sighting index is determined from the data and incorporated into estimates of the total number of females that laid eggs on a given night. The results of this approach will be compared to the standard estimates for nesting success at Raine Island and to the approach used by Valverde and Gates (1999) for arribada nesting olive ridley turtles. For the latter comparison, the time spent walking the transect lines was recorded and data on the time spent depositing the eggs were collected from 36 turtles.

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## **NEST DEPTH AND TEMPERATURE LIMIT THE CLUTCH SUCCESS OF FLATBACK TURTLES ON BARROW ISLAND, WESTERN AUSTRALIA**

**Claire Foster<sup>1</sup>, Kellie Pendoley<sup>2</sup>, Dorian Moro<sup>3</sup>, and Harriet Mills<sup>1</sup>**

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The clutch success of marine turtles is dependent on the environmental conditions (temperature, moisture and gas exchange) that eggs are exposed to during incubation. Industrial development that alters the physical environment of nesting beaches therefore has the potential to reduce the reproductive success of turtles. The flatback turtle has received little scientific attention in Western Australia, and the environmental variables which most affect its clutch success (and

are therefore critical for management) are unknown. This study documented the reproductive success of flatback turtles (*Natator depressus*) on beaches proximate to the proposed Gorgon LNG plant and offshore jetty on Barrow Island. Forty-six nests were marked during deposition in December 2007 on Barrow Island and monitored throughout incubation. Environmental variables were measured to assess which were related to clutch success. It was hypothesised that temperature and predation would be significantly related to clutch success, while nest location and sediment properties would not significantly affect the clutch success. The average incubation period of  $46.7 \pm 0.23$  days was shorter than that found in previous studies of flatback turtles from a natural nesting beach. Preliminary analysis revealed that deeper nests, which had cooler temperatures, had lower mortality in the final stages prior to hatching. Predation by varanids was lower than expected, with only one of 46 nests taken. There was no significant effect of nest location or sediment properties on clutch success. Ensuring adequate sand depth for the construction of deep nests may be important for the persistence of the flatback turtle population nesting on Barrow Island.

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## **THE ENVIRONMENTAL PROTECTION AGENCY'S MARINE WILDLIFE STRANDING PROJECT\***

**Jenny Greenland**

Environmental Protection Agency, Brisbane, Queensland, Australia

The Environmental Protection Agency maintains a database of marine wildlife strandings called StrandNet. This records information on the locations of injured, dying and dead marine turtles (as well as cetacean, pinnipeds and dugong) that have been found in Queensland. The Environmental Protection Agency assesses the cause of the injuries or death and summarises that information in annual reports. The stranding program began in the 1980s when the Queensland Turtle Conservation Project systematically gathered marine turtle mortality data for the wider Bundaberg beaches. This led to the declaration of the Woongarra Marine Park in 1991 and a directive to the team to monitor marine turtle mortality along western Hervey Bay from the Burrum River to the Kolan River. Marine wildlife strandings were also monitored in the wider Moreton Bay area. Over the next few years this was expanded to include the wider Hervey Bay and Cleveland Bay areas, which by 1995, were being well covered. The success of the Stranding Program was such that it now covers the entire Queensland coastline. Most reports of individual strandings are supplied by staff of the EPA and GBRMPA. Some of those reports come in via the statewide stranding hotline, 1300 130 372. Other reports come from rescue organizations such as Sea World, Underwater World and Australia Zoo and the general public. The database also contains mortality records from the Queensland Department of Primary Industries and Fisheries Shark Control Program. The stranding data has been instrumental in catalyzing multiple management changes with respect to marine park and fisheries management in Queensland over the past decade.

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## **MACKAY AND DISTRICT TURTLE WATCH ASSOCIATION - BUILDING, MAINTAINING AND CONTINUING OUR COMMUNITY PARTNERSHIPS**

**Ken Griffin<sup>1</sup>, Cath Maclean<sup>2</sup>, and Mark Hamann<sup>3</sup>**

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Mackay and District Turtle Watch Association (M&DTWA) is a group made up of enthusiastic volunteers who monitor turtle nesting beaches in the Mackay region of Queensland. They collect data on nesting sea turtles, sand temperatures, hatchlings and stranded marine animals. M&DTWA generates effective community engagement and networking skills and has strong support from many different Government and non-governmental agencies and community groups. Through the years they have developed partnerships with Environmental Protection Agency, Great Barrier Reef Marine Park Authority, James Cook University, Reef Catchments Mackay Whitsunday Inc, Regional Councils, Landcare groups, Queensland Parks and Wildlife, Conservation Volunteers Australia, Mackay Local Marine Advisory Committee, many different schools in the area, media contacts and the general community. The group has been

extremely successful in collecting priceless data, securing funding for interpretive signs at 15 known nesting beaches, establishing turtle friendly lighting, distributing informative brochures, displaying items for attendance at community events and educating 1,000s of school children and community members. The group has learned that to be a successful volunteer group it is important to establish and maintain relations with local communities and different organisations. To foster these relationships, the M&DTWA attends many community and local school events to educate the broader Mackay Community. Part of this is increasing the community's awareness of how to successfully and responsibly enjoy turtle watching. Through their consistent work, they have established a sense of ownership for community members that encourages responsible behaviour and an understanding of guidelines to maintain the health and successful breeding of marine turtles. The M&DTWA has also played a significant role in assisting with turtle research activities. The group has long-term data sets on flatback turtles and their nest site selections, beach temperatures and hatchling production. More recently, members of the group assisted in a project investigating the swimming and diving behaviours of flatback hatchlings. In this presentation we will provide an overview of our association and the collaborative work that we have been conducting over the last 15 years in the Mackay Region of Queensland.

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**TWENTY YEARS OF NESTING, HATCHING AND EMERGENCE SUCCESS OF FLATBACK SEA TURTLES (*NATATOR DEPRESSUS*) IN THE BARE SAND ISLAND DISTRICT OF FOG BAY, NORTHERN TERRITORY, AUSTRALIA\***

**Michael L. Guinea**

School of Environmental and Life Sciences, Charles Darwin University, Darwin, Northern Territory, Australia

Bare Sand Island, situated in the northern region of Fog Bay, is the centre of flatback sea turtle nesting in the Darwin region. An estimated 300 flatbacks nest on Bare Sand Island annually with possibly another 200 individuals that utilize beaches on nearby islands and the mainland. Peak nesting occurs in the austral winter months of June, July and August. Nesting density and intensity decreases from the island and along the mainland coast and nearby islands. Annually, the numbers of nests laid in various areas in a known period and the success of those nests have been assessed opportunistically. Within this population, nesting success and hatching success varied both spatially and temporally. Nest survival decreased with wind strength, tide height and swell. Egg predation was most common on mainland beaches, while hatchling predation was most common on island beaches. Novel beaches were sometimes utilized by nesting turtles. The beaches in the region have a varied history including a bombing range, freehold development, native title claim, urbanisation, and conservation areas. The Bare Sand Island population of flatback sea turtles remains healthy and is the focus of non-profit, community, conservation and education organisation AusTurtle Inc.

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**THE MONITORING, CONSERVATION & SECURING THE FUTURE OF FLATBACK TURTLES (*NATATOR DEPRESSUS*) IN PORT HEDLAND, WESTERN AUSTRALIA\***

**Kelly Howlett**

Care For Hedland Environmental Association, Inc., Port Hedland, Western Australia, Australia

There is a lack of data regarding turtle populations on the northern New South Wales coastline. Australian Seabird Rescue (ASR) is undertaking the "Make Turtles Count" project, with funding from the WWF Threatened Species Network and support from NSW National Parks and Wildlife Service, Cape Byron Marine Park and Southern Cross University. The project will seek to activate and inform a large number of volunteer participants to undertake daily patrols of nesting beaches in the region during breeding season (November 2008 to April 2009), enabling ASR to collate and publish the nesting data for ongoing management strategies and community awareness activities. In addition, the project will undertake population surveys of coastal reefs and adjacent areas on a quarterly basis in the Northern Rivers Region of NSW to allow for population comparisons during both breeding and non-breeding seasons. The flatback turtle (*Natator depressus*) is the only species of marine turtle endemic to Australia. Flatback turtles are

classified as vulnerable due to human activities that threaten the species. Port Hedland is 1,800km north of Perth, in the resource-rich Pilbara region of Western Australia. Port Hedland is situated on the traditional land of the Kariyarra people. But much has changed in the Port Hedland area, particularly with the lifting of the iron ore export embargo in the late 1960s. The dredging and transformation of the mangrove harbour and an array of other mineral resources has in recent times lead to the Port Hedland harbour as one of the largest bulk tonnage ports in Australia. Today with a population of 16,000 people, Port Hedland and its associated beach areas are a far cry from what they once were. Each of the Port Hedland beaches represents a unique monitoring and management opportunity and is predisposed to a number of threatening factors that could detrimentally affect the turtles nesting in the area: high levels of disturbance by people (direct contact, off road vehicles, harbour dredging, tourism & disturbance of nests and Indigenous take), residential lighting and feral animal predation. The monitoring methods used are based on a track identification method to determine the distribution and abundance of marine turtles during nesting. It also enabled the documentation of successful nests, hatchling emergence and any apparent disturbances such as nest predation by the European red fox or human disturbances such as off road vehicles and inappropriate turtle interactions. This project is still in its infancy but has already been able to deliver quantifiable data that has been able to be input into management decisions, particularly in regards to the impacts of fox predation, land-based recreational activities and proposed residential developments. It has also promoted the development and distribution of an array of education materials, including a Port Hedland specific "turtle watching code of conduct" that has greatly raised awareness about flatback turtles and the threats to these local populations to local community and tourists.

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## **QUEENSLAND TURTLE CONSERVATION PROJECT: AVOID ISLAND FLATBACK TURTLE STUDY 2007-2008\***

**Michelle Jones and Janene Metcalfe**

Environmental Protection Agency, Brisbane, Queensland, Australia

Avoid Island is a continental island that lies within the Broadsound area of the central Queensland coast between Mackay and Rockhampton. Historic aerial surveys conducted in the early 1970's and aerial and ground surveys conducted in the early 2000's identified Avoid Island as a major rookery for the eastern Australian breeding stock of flatback turtles. In May 2006, the Queensland Trust for Nature purchased Avoid Island. The Trust is a not-for-profit organisation established by the Queensland Government for community benefit. The Trust operates a revolving fund which is used to buy, conserve and resell strategically valuable tracts of land. The Trust's public fund was set-up from a seed funding donation of \$5 million from the Queensland Government. This is a new approach to protecting and conserving species and their habitat. Because of its potential as a major nesting area for flatback turtles in eastern Australia and the lack of in-depth data for this site, a 2-week census of turtle nesting activity during the peak season in 2007 was conducted by the Freshwater and Marine Sciences Unit of the Queensland Environmental Protection Agency (EPA). This was followed two months later by a week long census of incubation and emergence success. The results indicate that Avoid Island supports a medium-high density nesting population of flatback turtles annually and that the rookery is an excellent incubator for flatback turtle eggs and highly successful at contributing to the overall population of flatback turtles. The Trust has submitted a recommendation to the Department of Natural Resources and Water to extend the current 30-year lease of the island to a new 50-year lease. The Trust is also negotiating the closure of 75% of the current esplanade to include the nesting beaches of the island in the conservation agreement tied to the lease from DNR&W. The Island will be advertised for sale to the general public with the conservation agreement attached to the lease, binding the future landowners to the on-going protection of Avoid Island's species and habitats, including the turtle nesting beaches.

## **INDIGENOUS MANAGEMENT OF MARINE TURTLES IN NORTHERN AUSTRALIA\***

**Rod Kennett, Daniel Oades, Kevin George, Frank Loban, Lachlan Sutherland, Tonya Murray, Vanessa Walsh, Libby Larsen, Balapulu Yunupingu, Chris Roberts, Steve Johnson, and Graeme Friday**

North Australian Indigenous Land and Sea Management Alliance, Jabiru, NT, Australia

The NAILSMA Dugong and Marine Turtle Project (DMTP) facilitates Indigenous communities across northern Australia working together to protect threatened sea turtles and dugongs and their coastal habitats. Indigenous rangers and community members from the Kimberley, Northern Territory, Gulf of Carpentaria, Cape York and Torres Strait are working with government organisations, scientists, industries and other stakeholders to map and protect sea grass beds; clean beaches and rescue stranded wildlife, tag turtles and monitor turtle nests; record and share traditional knowledge about turtles and dugongs; and educate and raise awareness about the need to look after turtles and dugongs. Building local capacity and sustainable partnerships to support ongoing community activities are essential to the NAILSMA DMTP. Northern Australia is one of the last great strongholds for marine turtles and dugongs on the planet. With home ranges that cross borders and seas, these migratory species face a diverse range of threats and impacts that, collectively, have decimated populations elsewhere around the world. Maintaining Australia's dugongs and marine turtles requires effective partnerships, networks and collaborations that span northern Australia and indeed the SE Asian region. Northern Australia is also home to some of the longest running, intact land and sea management regimes in the world. Indigenous communities of northern Australia maintain long-held rights and responsibilities for land and sea management and continue to enjoy dugongs and marine turtles as a significant natural and cultural resource. There are numerous examples demonstrating the ability of Indigenous Australians to combine traditional and contemporary skills, knowledge and expertise for better resource management, and for northern Australia, Indigenous land and sea managers are the only management presence. The NAILSMA DMTP represents governmental recognition that effective and sustainable management of dugongs and marine turtles requires a community-based approach that builds on the strengths, skills and expertise of Indigenous people and is driven by the concerns and issues identified by Indigenous people. The collective expertise of the Indigenous participants in the project, coupled with the networks facilitated through NAILSMA and the partnerships being forged with government and other stakeholders, is making significant contributions to the sustainable management of dugongs and marine turtles.

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## **GREEN TURTLE NESTING POPULATION MONITORING, MAIZAB KAUR (BRAMBLE CAY)\***

**Frank Loban<sup>1</sup>, Eddie Sailor<sup>2</sup>, and Kristen Weiss<sup>3</sup>**

<sup>1</sup> Torres Strait Regional Authority, Thursday Island, Queensland, Australia

<sup>2</sup> Erub Community, Darnley Island, Queensland, Australia

<sup>3</sup> James Cook University, Douglas, Queensland, Australia

The Erubam le Turtle and Dugong management plan in the eastern region of the Torres Strait Islands has been endorsed for over 2 years and an enormous amount of voluntary work has been put into the plan right up to its present endorsed state. Maizab Kaur (Bramble Cay) is a story place for Erubam le and has a significant green turtle rookery in the northern Great Barrier Reef. Erubam le have concerns about the condition and health of Maizab Kaur, given the effect of erosion on turtle nests and the exposure of sedimentary rock that has trapped and killed large numbers of nesting turtles. Within the last two years, in late November and early December, Erubam le and project collaborators have been coordinating turtle nesting and hatchling success programs on Maizab Kaur, approximately 50 km north of Erub in the eastern region of the Torres Straits, Australia. The project is a collaboration between James Cook University (JCU), Torres Strait Regional Authority (TSRA) and the North Australian Indigenous Land and Sea Management Alliance's (NAILSMA) Dugong and Marine Turtle Project—which is funded by the Natural Heritage

Trust (NHT). Volunteers have been measuring variations in cliff height and recording turtle mortalities. Sand temperature loggers were installed at Maizab Kaur to monitor sand temperatures as part of a JCU PhD candidate's project. Participants in the project have included Erubam le T&D Project Officers and Traditional owners of Maizab Kaur the Peidu Clan, Project Officers, rangers, volunteers from various islands throughout the Torres Straits, Torres Strait Regional Authority project staff, and JCU marine biologists. One of the primary achievements through the Maizub Kaur Turtle Nesting and Tagging Project is community empowerment. This is the first time the Erubam le has participated in such a project, especially with a culturally significant species such as the green turtle. Last year almost 30 turtles were tagged and measured. This data is recorded and kept by the Erub Project Officer and JCU. Another achievement is that Project Officers, Erubam le traditional owners and attendees are getting first hand experience and training in turtle nesting surveys, tagging, and measuring nesting turtles on Maizab Kaur. These results benefit our community and assist other communities in showing how our management of the Turtle & Dugong populations are affecting these areas and what can be done to sustain our T & D populations for future generations. The skills developed on this project will allow the participants to better understand and improve the impacts that may arise from mismanagement of T & D populations. We want to use the information collected at Maizab Kaur to direct us in how we can address the erosion risk and decrease the impact this is having on our nesting turtle stocks.

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## **INDIGENOUS HUNTING OF MARINE TURTLES IN AUSTRALIA: CONSERVATION CHALLENGE OR OPPORTUNITY?\***

**Helene Marsh**

James Cook University, Townsville, Queensland, Australia

The waters of northern Australia support globally significant populations of six of the world's seven species of sea turtles. Sea turtles have great cultural significance for the Indigenous coastal peoples of northern Australia. Archaeological evidence suggests that the dugong has been harvested by the Indigenous peoples of northern Australia for at least four thousand years. As dugongs and green turtles are hunted together, it is likely that green turtles have been harvested for a similar period. Scientific evidence suggests that green turtles may now be over-harvested by some Indigenous communities in northern Australia. Some Traditional Owners share the scientists concerns. Nonetheless, the sustainability of the harvest is uncertain in most parts of northern Australia and the Australian green turtle population is large relative to many other parts of its range. Australia's highest court has decreed that turtle hunting is a Native Title right. Traditional Owners potentially also have shared title over their sea country out to 12 nm from the coast and offshore islands. In the Northern Territory, Traditional Owners also have exclusive title over the intertidal zone (which is extensive because the tidal range is large) and more than 80% of the coastline is under Indigenous ownership. These decisions by the High Court have provided a legal imperative for national and state governments to adopt a 'National Partnership Approach' to the management of turtle and dugong hunting. This policy aims to foster partnerships between government and Indigenous communities to discuss the sustainable harvest of turtles and dugongs, and to understand the experiences and aspirations of Indigenous Communities for managing their harvests. The Dugong and Turtle Project conducted by the Northern Australian Indigenous Land Sea Management Alliance in association with the Torres Strait Regional Authority has made significant progress in working with some communities to develop community-based turtle and dugong hunting management plans. In addition, community-based management of the turtle and dugong harvest is a catalyst for the development of broader initiatives to encourage Indigenous communities to be actively involved in the management of their sea country such as the Traditional Use Resource Management Agreements being developed in the Great Barrier Reef Region. The resultant stimulus for sea ranger programs is seen as an opportunity to: (1) help address the social problems in remote Indigenous communities; and (2) protect Australia's biological and cultural diversity. A recent global assessment identified the coastal waters of tropical Australia as the world's least impacted tropical marine region. These waters also adjoin Southeast Asia, the global center of marine biodiversity. The future of Southeast Asian coastal seas is much less certain than those of northern Australia because human impacts in Southeast Asia are already very high and increasing. Thus the global biodiversity significance of the coastal waters of tropical Australia is expected to become relatively more important over the next few decades. The meaningful involvement of Indigenous Australians in partnerships to manage their sea turtle harvest has the potential to help conserve global marine biodiversity as well as sea turtles per se.

## **WESTERN AUSTRALIA'S NINGALOO TURTLE PROGRAM: COST-EFFECTIVE THREAT-BASED CONSERVATION INVOLVING COMMUNITY, GOVERNMENT AND NON-GOVERNMENT ORGANISATIONS\***

**Roland Mau<sup>1</sup>, Susie Bedford<sup>2</sup>, David Waayers<sup>3</sup>, Raquel Carter<sup>4</sup>, Kate Macgregor<sup>2</sup>, Paul Gamblin<sup>5</sup>, Catherine Samson<sup>6</sup>, Kim Onton<sup>7</sup>, Brooke Halkyard<sup>7</sup>, and Amy Lewis<sup>1</sup>**

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<sup>6</sup> Department of Environment and Conservation, Karratha, Western Australia

<sup>7</sup> Department of Environment and Conservation, Bunbury, Western Australia

The implementation of effective threat response strategies for marine turtle conservation requires efficient use of scarce resources to achieve adequate conservation outcomes. The Ningaloo reef region off northwestern Western Australia provides foraging, mating and nesting habitat for green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*) turtles. In 2001, the Ningaloo nesting turtle population was experiencing increased pressure from recreational and commercial tourism activities, as well as non-quantified long-standing predation from the introduced European red fox (*Vulpes vulpes*). About 280 kilometres of the Ningaloo coast lies within a marine protected area and all species of marine turtles are protected under State and Commonwealth legislation in Australia. The Department of Environment and Conservation (DEC), the local community conservation group (CCG), Murdoch University (MU) and the not-for-profit Threatened Species Network (TSN) through the Worldwide Fund for Nature (WWF) established the Ningaloo Turtle Program with the goal of promoting the long-term survival of turtle populations in the Ningaloo region and beyond. Fundamental to this collaboration was a Steering Group which defined the direction and priorities of the program. There were significant funding opportunities from government and the private sector for community-based conservation projects at this time and the alliance was able to take advantage of these. The International Union for the Conservation of Nature (IUCN) Marine Turtle Specialist group standard beach monitoring method was adopted using competency-based training and skills assessment techniques. Amongst other reasons, this method was chosen as it allowed flexible participation by local volunteers. GPS fixed spatial nest location data was used to identify and map new indicative nesting rookeries for provision to government-managed Geographical Information Systems. This information was timely and relevant as it fed into a coastal planning process for the Ningaloo region. Beach closures to vehicles and car park relocations were implemented with minimal community opposition, as an appreciation of local nesting turtles had developed. An adaptive management fox control program was implemented where fox predation was significant, resulting in a reduction of nest loss to less than 5%. A turtle interaction licensing moratorium was introduced and community volunteers assisted in nighttime education of visitors. Development of a nationally accredited turtle tour guide training course and DVD ensured guides have basic knowledge and understanding of turtle biology and the interaction Code of Conduct for beach-based interactions. Several visitor-turtle interaction impact studies were conducted. The Guide training course is delivered by the local technical college with opportunities for employment during the region's "low" tourism season. Training in beach monitoring and interactive turtle tour guiding has been extended to indigenous Australians and community group members engaged in marine turtle conservation projects elsewhere. The Ningaloo Turtle Program was designed to build capacity within the local community. This includes a progressive training regime which allocates responsibility across a broad community base with the aim of removing dependence on founding individuals and encouraging community-perpetuation of the program.

## **COMMUNITY INVOLVEMENT: THE ROAD FROM VOLUNTEERING TO SCIENTIFIC SPECIES GAIN**

**Glenn C. McFarlane**

Conservation Volunteers Australia, Darwin, Northern Territory, Australia

Conservation Volunteers Australia (CVA), a national, not-for-profit organisation, engages members of the community on a range of practical conservation programs both within Australia and overseas. CVA's programs now include a focus on key species and habitat protection with outcomes supporting the wider scientific community, including the sea turtle monitoring and habitat protection programs across nesting and foraging grounds of Northern Australia. Milestones in CVA's history include: (1) the establishment of the CVA World Conservation Program and International Conservation Volunteer Alliance - For the past 20 years, international relationships with not-for-profit organisations and governments have been maintained through conservation volunteer team exchanges and staff training. Programs in the USA, Central and South America, Europe, Asia and Africa have allowed volunteers and staff from a range of organisations to work towards achieving the common goals of each international program through best-practice participation; (2) Global and Local Recognition - On World Environment Day 2000, CVA received the United Nations' highest environmental award - the Global 500 Honour Roll for Environmental Achievement. CVA has been recognised with many other awards in Australia, including 5 Banksia Awards; (3) Supporting Key International Nesting Stocks of Leatherbacks, Hawksbills and Greens - CVA's World Conservation Program continues to support sea turtle conservation and research projects in Costa Rica with Australian volunteers six years after the initial team visited Cahuita National Park. Volunteers built the Park's first secure hatchery at this vital hawksbill nesting location and this structure continues to reduce the annual local poaching rate. Active and ongoing participation, and training and assistance to turtle projects in Costa Rica and Panama have empowered CVA staff and volunteers to assist the wider Australian sea turtle community; (4) Community Education and Australian Project Development - With a focus on nesting grounds in the Northern Territory and the Kimberley coastline, CVA has in recent years undertaken marine debris surveys and dune stabilisation projects to protect nesting beaches, plus established a community-based turtle monitoring and research program. A key element is the ability to continue to engage and educate members of the community; (5) Development of Wild Futures - With over 12,000 volunteers and more than 2,000 practical conservation projects each year across Australia and New Zealand, CVA's Wild Futures initiative now adds a special focus to conservation work critical for the survival of some of our most threatened wildlife. Significant project support and development of future sea turtle initiatives will further increase CVA's capacity to increase the level of scientific data, allowing informed management decisions to be made; and (6) Conservation Volunteers Australia has the ability to cross many borders with government, corporate and private sectors to achieve environmental goals and meet management plans, while remaining transparent as an organisation involved in sea turtle conservation and research both in Australia and internationally.

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## **COMMUNITY PARTICIPATION IN ECOLOGICAL MONITORING: THE BENEFITS OF USING VOLUNTEERS TO DETERMINE FLATBACK TURTLE POPULATION SIZE ON BARROW ISLAND\***

**Dorian Moro**

Chevron Australia Pty Ltd, Perth, Western Australia, Australia

Population models rely heavily on empirical data, ideally collected over long time periods. When used correctly and alongside robust ecological theory, models developed from primary data can provide an important base to manage species. The collection of data, however, can be time consuming and labour-intensive. Chevron Australia has operations on Barrow Island, on the North West Shelf of Western Australia, where plans for an LNG facility are underway. There is also an ongoing flatback turtle tagging program, which aims to determine the population size and dynamics of flatback turtles using nesting beaches proximate to the proposed LNG loading facility. Over the past three

years, between late November and the end of January, six east coast beaches on Barrow Island have been patrolled nightly and every nesting adult flatback turtle has been double tagged using titanium tags. Four teams of 12 turtle taggers are managed over the season by experienced supervisors. Taggers are trained in the field and work in pairs on each beach. All taggers are volunteers who have either taken annual leave for the experience or time off work to participate in the program for a 2-week shift. Volunteers benefit from the experience by receiving training and education in addition to a unique field experience. This experience is highly valued by the volunteers; community involvement in the project is demonstrated by the number of volunteers who elect to return each year. The success of such a program is attributable to careful planning and deployment of resources: scientific specialists to design the program within a scientific framework and analyse the survey data, and a host facility to provide the support infrastructure, and the health and safety services, to ensure the volunteers are provided with a safe working environment. We conclude that through industry engagement of community volunteers to participate in scientific field data programs, mutual benefits are obtained that enhance community understanding of how industry can co-exist with nature conservation.

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## **FLATBACK TURTLES: SPATIAL DISTRIBUTION AND REPRODUCTIVE BIOLOGY IN THE PILBARA REGION OF WESTERN AUSTRALIA\***

**Kellie Pendoley<sup>1</sup>, Milani Chaloupka<sup>2</sup>, and Jessica Oates<sup>3</sup>**

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Systematic research into the breeding biology of flatback sea turtles nesting in the Pilbara region of Western Australia has been supported by the Department of Environment and Conservation and the oil and gas industry (principally Chevron Australia) since the early 1990's. This research program is based on Barrow Island (3 years) and Mundabullangana Station on the mainland (10 years), and has focused on the flatback turtle nesting environment and hatchling orientation onshore, and the identification of internesting and foraging grounds offshore. Research indicates that approximately 1,600 females have nested annually over the past two seasons on Barrow Island, while the Mundabullangana Station nesting population is stable at >1,700 nesting females per year. The reproductive periodicity represented by remigration intervals suggests that Barrow Island flatback turtles had shorter remigration intervals of  $1.7 \pm 0.1$  years than Mundabullangana turtles which returned after  $3.1 \pm 0.1$  years. Over 50% of the turtles recorded in both populations remigrated within 1–2 years. The Barrow Island interval may increase as the number of years of monitoring increases. The recorded remigration intervals may be a reflection of the difference in the locations of foraging grounds documented during satellite telemetry studies on nesting females from the two populations. The results showed that at least two turtles forage locally on well-defined foraging grounds within 100 km of their nesting site at Barrow Island, while others travel to sites over a 1,000 km north in the far northern Kimberley. The results also suggest that some of the flatback turtles do not exhibit strong foraging site fidelity and are constantly moving between foraging sites. The peak internesting periods also differed for both populations; the range of 13–16 days (mean=14.7 d) for the Barrow Island population was significantly longer than the 10–13 days (mean=12.6 d) at Mundabullangana Station. The satellite telemetry results also identified a difference in the locations of internesting habitats for the two populations; all of the Mundabullangana flatback turtles remained within 10–20 km of their mainland nesting beach while the Barrow Island turtles traveled 60 km to internesting grounds at the mainland between each internesting cycle. The time required to travel the extra distance to the mainland internesting sites may account for the longer internesting intervals at Barrow Island.

## **SEA TURTLES IN THE WESTERN AUSTRALIAN REGION: WHAT DO WE NOW KNOW/STILL NEED?\***

**Robert Prince**

Wildlife Research Centre, Dept of Environment & Conservation, Wanneroo, Western Australia

Knowledge of sea turtles within the western Australian region was limited prior to the mid-1980s. The Western Australian Marine Turtle Project, a regional long-term focal programme, was formed which initiated resource discovery, species populations research, management application and community engagement. The project has helped improve our knowledge of the regional sea turtles and their resources. Much greater attention is now also afforded to sea turtle matters in biodiversity conservation and environmental management considerations. A deeper understanding of the nature of the species populations and their demographics has proven more elusive, despite planning for such results. In this presentation I will provide a synopsis of the current database, as well as the gaps that still need to be filled.

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## **PROTECTING WESTERN AUSTRALIAN SEA TURTLES THROUGH GOVERNMENT AND INDUSTRY PARTNERSHIPS**

**Fran Stanley, Robert I.T. Prince, Geoff Kregor, and Marissa Speirs**

Department of Environment and Conservation, Western Australia

Western Australia (WA) is home to globally significant populations of sea turtles, with five of the seven species nesting on the State's northern coastline and islands. Many important turtle rookeries and feeding sites closely coincide with onshore and offshore resource industry facilities. Thus, the potential exists for detrimental impacts on these turtle populations. Since the 1980s when rookery locations were first identified for nesting sea turtles in the State, WA's Department of Environment and Conservation (DEC) has been collaborating and developing partnerships with the petroleum and mining industries to study, manage and conserve important nesting beaches and the turtles that rely on them. These include beaches on Barrow and Thevenard Islands, Varanus Island, and in the Dampier Archipelago, where partnerships have been developed with Chevron Australia (formerly WAPET), Apache Energy and Woodside Energy, respectively. On the mainland coast, BHP Billiton Iron Ore and Rio Tinto have contributed to turtle monitoring programs near Port Hedland and in the Dampier Archipelago, respectively. These latter two companies operate large port and shipping facilities to export iron ore, which lie near turtle habitat and rookeries. The DEC has the responsibility of conserving and managing WA's fauna but often limited funds to support research, monitoring and management programs, particularly in the remote northwest of WA. Turtle tagging and monitoring programs have been supported by Chevron, Apache Energy, Woodside Energy, BHP Billiton Iron Ore and Rio Tinto over many years, both financially and in-kind. Access to island accommodations and transportation has been provided to allow DEC staff and volunteers to monitor turtle activity. In many cases, volunteers were sourced from within the industry through companies promoting monitoring programs and offering incentives for staff to participate. The partnerships have also led to cooperative management of development and operational activities to ensure that potential impacts on sea turtles are avoided or limited. This has included developing and implementing appropriate lighting regimes to reduce the amount of light visible to nesting females and hatchlings on beaches near industry facilities, siting pipelines to reduce impacts on nesting beaches, using open pile jetties rather than solid rock constructions to allow freedom of movement for turtles along island coastlines and reduce changes in coastline structure, and managing recreational access by staff outside of work to turtle nesting beaches. The DEC and industrial companies promote the importance of turtles to the region. The reasons for imposing certain rules create a sense of stewardship of sea turtles and often appears in promotional material. Increased workforce and public awareness was also achieved through personal experiences as turtle monitoring volunteers. Without the continued support of the petroleum and mining industries through the partnerships that have been developed with DEC, WA's turtle tagging and monitoring programs would not have been as extensive or diverse and our knowledge of sea turtles along WA's vast northern coastline would likely be far less.

## **GREEN TURTLE INTERTIDAL BASKING AGGREGATION FIDELITY IN GREAT SANDY MARINE PARK\***

**Aub Strydom**

University of Queensland, Gatton, Queensland, Australia

Great Sandy Marine Park, declared by the Queensland Government in 2006, is an integral part of the Great Sandy World Heritage listed area. It includes the Sandy Straits RAMSA declared wetland, the former Hervey Bay Marine Park and Woongara Coast and Mon Repos Turtle Conservation Zones. In 2006, Queensland Parks & Wildlife became aware of aggregations of green turtles “basking” on the exposed muddy beds of small mangrove lined creeks during the low tides in the Great Sandy Marine Park. Five sites over a 1.5 km area of mangrove foreshore near Hervey Bay were identified and within three months a small group of QPW volunteers tagged over 200 green turtles of all age classes. To date, about 350 turtles have been tagged while basking in the first and fifth creeks. Additionally, 85 turtles were tagged in a 6th creek-marina complex 1.5 km further north, and 30 turtles were tagged in the 6km of mangrove forest to the south of the first creek. The aim of this project was to establish the extent of fidelity to basking location, by age class, of the green turtles observed basking in Great Sandy Marine Park. The results of this study will be applicable by providing information for: 1) Habitat Protection by State & Local Government: There are many residential, commercial, and recreational developments close to mangrove creeks with known turtle basking activity, and these developments could impact the structure of the mangroves and creeks and therefore the lives of the turtles (e.g. disturbance by fishing and other human activities, including boat strikes, entrapment in crab pots, increased litter stream with plastic ingestion causing intestinal blockages, and attacks by increasing numbers of unrestrained domestic dogs.); and 2) Sustainable Traditional Hunting: The green turtles of Hervey Bay are used by the traditional owners, the Butchulla. While some turtles are known to have been taken from the study area during 2006-7, little is known about the level of harvesting in the Marine Park. The project aims to sample turtles basking at other sites in the Great Sandy Marine Park to seek tag recoveries from the primary sites, and will examine the foraging data of “Caroline”- a breeding female green turtle from the northernmost primary site who was satellite tagged in July 2006. We will also use a Fastloc PTT satellite transponder to track the foraging movements of one turtle commencing in the latter part of 2008. To date there is insufficient data to draw clear conclusions; however, I have three *a priori* hypotheses: 1) Complete fidelity to one site: The turtles always use one “home” creek; 2) Fidelity to more than one site: The turtles have a series of “base camps” scattered around their feeding area, and will cycle through the various sites on a regular or random basis; and 3) No fidelity: The turtles will bask ashore anywhere near where they are feeding at the time.

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## **COLLABORATIVE APPROACH TO MARINE TURTLE CONSERVATION AND TOURISM IN THE NINGALOO REGION, WESTERN AUSTRALIA\***

**David A. Waayers**

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Collaboration amongst stakeholders has emerged as a means of overcoming the fragmented nature of past conservation and tourism planning approaches. The fragmented nature of these industries is often associated with the lack of coordination as there are many different stakeholders who have interests in conservation and tourism. Collaboration is a formal institutional relationship among existing networks of institutions, interests and/or individuals. It is a process for joint decision making involving key stakeholders sharing a common problem with a plan for resolving conflicts and advancing visions. The involvement of stakeholders in the planning process can lead to more informed decisions about management and contribute to issues of accountability and stakeholder acceptance of policy. Whilst there is a wealth of literature that explores the theory and conceptual ideas of collaboration in protected area and tourism planning, there is a real need to explore these theories in real life situations. This paper presents a case study that examines the extent of stakeholder collaborations in the development of turtle conservation and tourism in the Ningaloo region, Western Australia. The Ningaloo region was selected as a case study because the area is a well-established, popular wildlife tourism destination in Australia, it offers a variety of natural, recreational and cultural pursuits and the community has a strong affinity with the natural environment. Turtle conservation and tourism in the Ningaloo region was also selected

because it displayed characteristics of a fragmented planning process that suffered from limited collaboration between government agencies, industries and local community groups. The establishment of the Ningaloo Turtle Advisory Group (NTAG) was seen to be a positive step forward in attempting to address these problems through a series of workshops in 2003 and 2004. This paper explores the extent to which a collaborative planning approach is achieved and the key factors that hinder or assist the development of NTAG. The methods used to gauge the nature and extent of collaboration amongst stakeholders involved examining workshop dialogue, which was also complemented by action research techniques. It examines the establishment of NTAG, how its vision and objectives were derived, evidence of collaboration and coordination between the multiple stakeholders and input from stakeholders. This research showed that the initial success of collaboration relies on building partnerships and trust, recognising interdependence, generating a collective vision and objectives and commitment amongst stakeholders. The establishment of NTAG and associated efforts to collaborate amongst stakeholders indicates that turtle tourism and conservation is well within the process of developing a collaborative and strategic planning process. Nevertheless, the continuation of this process will depend on stakeholder's commitment to the process and above all the capacity of institutions and interest groups to transform collaboration into an ongoing learning process. Acknowledgements: I would like to thank the Department of Environment, Water, Heritage and Arts (formally Environment Australia), Department of Environment and Conservation, World Wildlife Fund for Nature and Tourism WA for their financial contributions. Special thanks to Roland Mau, Susie Bedford, Raquel Carter and all other stakeholders that contributed to the planning process.

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## **DOWAR TURTLE NESTING POPULATION MONITORING**

**Moses Wailu<sup>1</sup> and Frank Loban<sup>2</sup>**

<sup>1</sup> Mer Island & Torres Strait Regional Authority, Queensland, Australia

<sup>2</sup> Torres Strait Regional Authority, Queensland, Australia

Dowar is a major nam (green turtle) nesting rookery in the northern Great Barrier Reef (GBR). The Dowareb tribe is the traditional owner of Dowar and has been managing the island, and is the Meriam cultural custodian of the nam. As part of the NAILSMA Dugong and Marine Turtle Project, the Meriam people of Mer, Dowar and Waier Islands (MDW) have been monitoring many aspects of nam nesting in conjunction with the Torres Strait Regional Authority (TSRA) and James Cook University (JCU). The nam monitoring project on Dowar has been underway since 2006. The Dowareb tribe traditional owners have a detailed knowledge of nam. This knowledge has been used to coordinate the monitoring project, including determining the timing of the surveys as well as collaborating with the MDW traditional owners. Surveys include tagging, measuring and recording details of nam nesting activities as well as conducting subsequent hatching success surveys following each nesting season. The MDW turtle project officer coordinated all survey work and logistics of working on Dowar, obtained permission for access and involved the local school. Moses also facilitated MDW traditional owner and Mer school student involvement in the satellite tagging and subsequent tracking of two nam from Mer. A wide range of participants were involved in the survey work, including elders, hunters, school students, volunteers from the MDW community, project officers from islands in the Torres Strait, JCU researchers and officers from the TSRA. The project has collected nesting and hatching success data at Dowar over three nesting seasons that supports Dowar as an important nesting site in the northern GBR. Temperature and hatching success data collected at the site confirms it is a productive site for nam, with sand temperatures producing mainly female hatchlings, something confirmed by Dowareb traditional knowledge used to determine nam hatchling sex. The Dowar nam monitoring project is of great significance to MDW traditional owners, particularly the Dowareb tribe. This small project has involved many MDW and the community is very happy that work is being done to manage and conserve their turtles for future use and enjoyment, for spiritual connections and for the benefit of the wider community. The project is also of importance to the northern GBR green turtle population as Dowar and Mer are more stable rookeries and important for this genetic population's continued existence in the northern GBR.

## **COOLUM COAST CARES-TURTLE TROUBLES**

**Leigh Warneminde, Michelle Jones, Sherida Holford, and Susan Richards**

Marine and Fresh Water Sciences EPA, Australia

Coolum District Coast Care is a community group on the Sunshine Coast that has been operational for the past ten years. Three years ago, under the guidance of President Leigh Warneminde, four of us formed a group that dealt specifically with “Turtle Troubles”. After communicating with the Environmental Protection Agency and local Council, we applied for and obtained an Envirofund grant that allowed us to obtain equipment and training in order to collect data from stranded turtles on our local beaches. We measure, photograph and dispose of dead turtles, then forward this data to the EPA. Sometimes, depending on the condition of the carcass, turtles are sent to the University for a necropsy. We also transport live turtles to both Underwater World and the Australia Zoo Wildlife Hospital. It was then a natural progression for three of our members to travel to Mon Repos for training with nesting turtles. This coincided with one of our members immediately having to attend to a nest at Sunshine Beach and relocate the eggs due to erosion. From that point on we have actively monitored, meshed and collected data on our local turtle nests. We have also purchased a sand temperature data recorder which is supplying the EPA with vital information regarding our local beach temperatures. We now have five accredited members covering approximately a fifty kilometer stretch at the Northern end of the Sunshine Coast. The Envirofund grant has also allowed us to print stickers for every beach access in our area informing the public of the marine stranding hotline number. We have also supplied all local lifeguards and surf clubs with an information sheet regarding turtle tracks, giving us much needed assistance in locating the nest sites. Early morning walkers have also been enlisted as “turtle watch” volunteers on our Sunshine Coast beaches. Our group is constantly raising community awareness that the Sunshine Coast region is an important habitat for turtles. With population growth and development along our coastal fringes it is vital that measures are implemented to limit light pollution and dune destruction to give nesting turtles the best nesting opportunities.

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## **LOOKING AFTER SEA TURTLES IN THE NORTHERN TERRITORY: SEA RANGERS, COMMUNITIES, SCHOOL KIDS AND SCIENCE\***

**Scott D. Whiting<sup>1</sup>, Stephen Johnson<sup>2</sup>, Graeme Friday<sup>2</sup>, Thomas Simon<sup>2</sup>, Damian Pracy<sup>2</sup>, Samuel Evans<sup>2</sup>, Felicity Chapman<sup>2</sup>, Gavin Enever<sup>3</sup>, Simon Hartley<sup>3</sup>, Simeon Lalara<sup>3</sup>, Nathan Barra<sup>3</sup>, David Campbell<sup>3</sup>, Kate Hadden<sup>4</sup>, Jack Long<sup>4</sup>, Anthony Kleidon<sup>5</sup>, Ray Chatto<sup>1</sup>, Libby Larsen<sup>6</sup>, Anderson Lauder<sup>7</sup>, and Karen Edyvane<sup>1</sup>**

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The remote and inaccessible nature of the northern Australia coastline presents large logistic constraints to the monitoring of marine wildlife. The Northern Territory has a coastline of over 10,000 km long with Darwin (population 115,000) and Nhulunbuy (population 4,000) the only two coastal urban centres of over 800 people. However, with over 85% of the coastline being Indigenous-owned, many smaller Indigenous communities and Aboriginal outstations present opportunities for both marine wildlife monitoring and employment in remote areas. Currently in the Northern Territory there are 14 independent Sea Ranger groups, all of which have been established and funded through a variety of means including government, Aboriginal Land Council, local community and NGO assistance. The natural resource and social benefits of community based ranger groups are both varied and wide reaching. We present three project case studies of scientific monitoring of sea turtles by Indigenous Sea Ranger groups within the Northern Territory that highlight the importance of community-based projects to scientific data collection and coastal resource management.

The three case studies include the Tiwi Islands (with the Tiwi Land Council Marine Rangers), Sir Edward Pellew Islands (with the Lianthawirryarra Sea Rangers) and Groote Eylandt (with the Anindilyakwa Land Council Sea Rangers). Olive ridley turtles are the focus species at the Tiwi Islands with densities of over six nesting tracks per km/night in the peak of the season in April. Major sources of mortality are feral dog predation on eggs and saltwater crocodile predation on adult females. Flatback and green turtles are monitored through track counts on the Sir Edward Pellew Islands with an intensive two week camp focused on flatback turtles on West Island. This is a moderate density nesting beach with around four flatback turtles nesting per km/night at the peak of the season in September. Hawksbill turtles are studied on three islands to the NE of Groote Eylandt in the Gulf of Carpentaria. Although this research is in the early stages, the beaches of some of these islands support tens of nesting hawksbill turtles per km/night. All projects are ongoing and combine scientific monitoring, community participation, education and management. Highlights of some of the projects have involved: Indigenous rangers trained in collection of scientific data, identification of key nesting habitat, establishment of long-term monitoring methodologies, migration routes tracked by satellite telemetry, control of feral animals on the nesting beaches, community input to planning, community involvement and interactions between sea rangers and school students.

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## **DIVE! DIVE! DIVE! A FIRST ACCOUNT OF THE BEHAVIOUR OF YOUNG FLATBACK TURTLES IN THE FIELD\***

**Jeanette Wyneken<sup>1</sup>, Mark Hamann<sup>2</sup>, and Michael Salmon<sup>1</sup>**

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We measured diving behavior of flatback turtles (*Natator depressus*) during their first few weeks of development. During this time, the turtles grew (in SCL and in mass) on average from 6.4 cm and 37.1 g as hatchlings to 9.1 cm and 98.7 g as 7 week old post-emergence juveniles. Our turtles came from four nests. They were reared in large, shallow grey plastic tanks with circulating seawater and fed once daily an in-house manufactured gelatin-based diet containing ground fish, carbohydrates, and reptile vitamins and minerals. At 1-2 week intervals, several turtles were taken offshore by boat and released for a 30 min trial in nearshore waters adjacent to Townsville, Queensland, Australia (water depth: 6 – 14 m). Each turtle towed a small Lotek™ time-depth tag (TDR) made slightly positive in buoyancy by the addition of a thin streamlined layer of foam. When the trial ended, the tag was removed and the turtle was released. Most (21 of 22) of the turtles dove and 19 turtles made frequent ( $\geq 6$ ) dives during their trial. The range was 0-32 dives and among the frequent divers, the modal number was 10. The majority of dives typically had V-shaped profiles while a minority had W” profiles. “U” profile dives were rare. Flatbacks are strong, fast swimmers and are capable of descending 10 m at rates of 1.5 m/s, even at 1 week of age. However, most dives were less than 2 m with decent rates between 0.3-0.7 m/s. Flatback dives, unlike those of leatherback and green turtles of similar age, failed to show a correlation between dive duration and dive depth. Most flatback dives lasted less than 2 min. Longer dives lasting 3-6 min were in the minority but became more frequent with age (5% of the dives of 1 week old turtles; 10% at 3-4 weeks; just under 25% at 5-7 weeks). These changes suggest that flatbacks may undergo physiological shifts (such as an increase in blood volume, lung capacity, or a change in O<sub>2</sub> carrying pigments) with increased size/age so that longer dives become possible. Similar growth relationships were observed in juvenile green and leatherback turtles. The functional significance of the dives we recorded is unknown, but may be related to escape or to search for food. We tested the turtles in the same turbid coastal waters where they naturally occur and so we could not directly observe either their movements or their behavior. We hypothesize that flatback coloration makes them cryptic in turbid nearshore waters, that early in development they search for food in the water column (rather than on the bottom), and that they avoid the surface where they might be especially vulnerable to attack from aerial predators (e.g. coastal raptors).

## **BREEDING BIOLOGY**

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### **BODY WEIGHT AND THE ENERGY BUDGET OF GRAVID HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) DURING THE NESTING SEASON**

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Female hawksbill turtles (*Eretmochelys imbricata*) nesting along the southeast coastline of Rio Grande do Norte State, Brazil (6°13'40"S, 35°03'05"W) were captured and weighed during the 2006/2007 and 2007/2008 egg-laying seasons. The mean value for the first post-oviposition weight was 79.6 kg (range 56.2 – 105.7 kg; SD = 11.3 kg; n = 72 females). Those individuals which were subsequently recaptured showed a mean weight loss of 1.6 kg (range -3.7 – 5.1; SD = 1.43; n = 75 sets of measurements on 36 females) in the interval between two consecutive post-oviposition (i.e. after one interesting interval). In the cases where the female aborted the nesting process, the pre-oviposition weight was measured. The total effective egg-laying investment was found to be 5.46 kg (range 4.3 – 8.2; SD = 1.09; n = 12 sets of measurements). The mean recovery in body weight was found to be 3.2 kg (range 1.8 – 4.6; SD = 1.05; n = 9 sets of measurements). The recovery in body weight was found to be always significantly lower (p<0.005) than the total effective egg-laying investment. This is in agreement with the observed weight loss tendency throughout the breeding season for this species. The weight recovery was analysed using allometric law, converting both loss in body weight and total egg-weight to energy. Using mean body weight of the turtle we calculated that the metabolic maintenance rate of the hawksbill turtle during the nesting period to be 2870 kJ·d<sup>-1</sup> and the energy that the turtles expended in egg-laying to be 1183 kJ·d<sup>-1</sup>. The daily net weight loss converted into energy is 4213 kJ·d<sup>-1</sup>. The total daily energy consumption (maintenance plus egg production) is of the same magnitude as the daily energy from weight loss. We argue that there is no reason for a significant extra intake of energy during the oviposition period. Hence we conclude that the observed weight recovery is due to rehydration. Acknowledgements: Santuário Ecológico de Pipa, Projeto TAMAR ICMBio, Programa de Estudos e Pesquisas em Preservação Ambiental nas Áreas Marítimo Terrestre da Bacia Potiguar (IBAMA-UFRN-FUNPEC-PETROBRAS). We also thank the Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, US National Marine Fisheries Service, and the US Fish and Wildlife Service (Marine Turtle Conservation Fund) and the International Sea Turtle Symposium.

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### **A TRI-NATIONAL AERIAL SURVEY OF LEATHERBACK NESTING ACTIVITY IN NEW GUINEA AND THE SOLOMON ISLANDS**

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Western Pacific leatherback turtles have declined during the past two decades, and obtaining accurate estimates of current nesting population size is essential for future leatherback recovery. Telemetry studies conducted from nesting beaches in Papua New Guinea (PNG), Solomon Islands, and Papua Barat, Indonesia have revealed that this meta-population is comprised of multiple foraging populations that nest throughout the year. Declines have been apparent to local villagers in most areas, but conservation and protection is hindered by a lack of knowledge of nesting population size and distribution. Comprehensive regional aerial surveys were conducted along the north coast of New Guinea and adjacent islands, and throughout the Solomon Islands during January-February 2004-2007, and in July 2005. The objectives of the surveys were to determine significant nesting beaches outside of monitored areas and to lay the groundwork for estimating the nesting population size of Western Pacific leatherbacks. Leatherback nests were counted by 2-3 observers from a fixed-wing aircraft flying at 200 ft (61 m) altitude using established methods. Coordinated ground counts were conducted at 11 beaches throughout the region where monitoring and protection programs had previously been established, to allow estimation of errors associated with aerial detection of nests. The greatest densities of leatherback nests were encountered on the northern Bird's Head coast of Papua Barat, and along the Huon Gulf of PNG. Limited nesting was observed within the Solomon Islands, with the greatest number of nests on Santa Isabel Island. Previously undocumented nesting beaches were identified on Bougainville Island, including one large concentration on the south-eastern coast. Scattered nests were also observed on the northern and southern coasts of New Britain, PNG. This study represents the first tri-national assessment of Western Pacific leatherback nesting activity and results will be used to develop new monitoring and conservation programs at key nesting beaches.

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## **THE EFFECT OF RELOCATION AND KEY ENVIRONMENTAL FACTORS ON LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*) NESTS ON CAPE ISLAND, SOUTH CAROLINA, USA\***

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Cape Island is the northernmost barrier island of the Cape Romain National Wildlife Refuge located in Charleston County, South Carolina. This 10 km undeveloped beach supports the highest density nesting for the Atlantic northern sub-population of loggerhead sea turtles (*Caretta caretta*), an area that extends from Amelia Island, Florida through Virginia. In order to determine the effect of nest relocation on hatch success, emergence success, incubation duration, and incubation temperature during the sex-determining period, relocated and in-situ nests were monitored throughout the entire 2008 nesting season. This study is an expansion of a 2007 study that compared in-situ nests to nests relocated into hatcheries during June and July. Key environmental factors such as sand characteristics, vegetation, and elevation were examined in both relocated and in-situ nests. MicroDAQ LogTag temperature data loggers with a  $\pm 0.1^{\circ}\text{C}$  were placed in the approximate center of relocated nests and in-situ nests during the entire incubation duration. Sediment samples were collected 1 m from each nest with a push core representing an integrated average of sediment characteristics within the egg chamber. Vegetation was determined by counting stems and identifying plants to the lowest practical taxonomic level around each nest. The elevation of each nest was determined using a Trimble R-8 GPS unit. Preliminary analysis of the data indicates there are no differences in elevation, vegetation, incubation duration, hatch success, emergence success, or sediment characteristics except moisture content between in-situ and relocated nests. These preliminary results suggest that nest relocation on Cape Island is an effective management tool. Thanks go out to the Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), the Marisla Foundation, and the International Sea Turtle Symposium for providing travel funding.

## **FIRST EVER POPULATION CENSUS OF NESTING LOGGERHEADS ON SAL ISLAND, CABO VERDE**

**Jacque Cozens, Manuel Pereira, Edson Mendes, and Rachel Miles**

SOS Tartarugas Cabo Verde

Only sporadic and limited data collection has been undertaken in this important nesting area. SOS Tartarugas began intensively monitoring the five main nesting beaches in June 2008. In addition, weekly surveys have been conducted throughout the entire island giving the first ever complete census. Tagging has been conducted throughout the entire season for the first time. The data collected will give important information regarding future tourism development on the island as many nests have been laid on beaches believed to be unused by turtles. This will be of particular use regarding the development of marinas currently planned in areas of high turtle activity. The data will show population size, beach fidelity, inter-island nesting, nesting frequency and other previously unrecorded information. It will also compare hatching success between the hatchery, in situ and trans situ nests. In addition, we will have reliable data about the number of turtles killed by hunters. The data will be part of the new national database that is a collaboration between the NGOs working in Cabo Verde. The data will be presented to the government and incorporated into their National Plan for the Protection of Marine Turtles.

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## **SWOT TECH SUPPORT – BRINGING THE SWOT GLOBAL SEA TURTLE DATABASE ADVANCED MAPPING CAPABILITIES AND NEW UTILITIES**

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The State of the World's Sea Turtles project (<http://www.seaturtlestatus.org>) has spent several years acquiring data and is now publishing its 4th annual report. From the beginnings of an idea, and an initial publication dealing strictly with global nesting for one species, it has blossomed into the only global nesting database for 4 species of sea turtles and is "getting wet" by starting to aggregate in-water data as well. Recently, the SWOT scientific advisory board has made great inroads into increasing SWOT's visualization and organizational capabilities with a concurrent thrust to improve overall data quality via its development of minimum data standards and a commitment to pursue the best ways to organize and store data. Here we briefly highlight the SWOT database's new structure, and then examine in depth the new mapping/querying capabilities afforded the database by taking advantage of a partnership with Duke University's Marine Geospatial Ecology Lab's Ocean Biogeographic Information System - Spatial Ecological Analysis of Megavertebrate Populations (OBIS – SEAMAP 2.0 <http://seamap.env.duke.edu>). Also included will be a discussion of new features available to both the SWOT team and the sea turtle community at large that are being developed specifically for the SWOT database. The SWOT database is now hosted by SEAMAP. SEAMAP features not only excellent user agreements for the protection of data providers, but also advanced mapping and querying capabilities such as the easy import of remotely sensed oceanographic data, spatial queries and database queries, the ability to make plots associated with the visualized data, and truly awesome visualization using both open source (Google Earth) and proprietary programs and techniques – the power and versatility of all these features are now available to the SWOT team as well as the wider sea turtle community. In addition to the standard suite of SEAMAP features, additional utilities are being developed for use specifically with the SWOT database. These include online data upload and management, delineation of geographic features, spatially explicit interannual variability maps, and greatly increased ease of contribution to the global sea turtle knowledge base. Expansions of the utilities described here will include integration of SWOT's newly developed minimum data standards into the online data submission process, addition of in-water data to the larger SWOT database and more, as we garner feedback from the SWOT team and the larger sea turtle community.

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## **50 YEARS DOWN THE WINDWARD ROAD: REFLECTIONS ON SEA TURTLE POPULATIONS AT TORTUGUERO, COSTA RICA\***

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In 2009 the Caribbean Conservation Corporation will celebrate 50 years of sea turtle research and conservation at Tortuguero, which began with the arrival of Dr. Archie Carr at a small, isolated village on Costa Rica's Caribbean coast. Since then the work conducted by CCC at Tortuguero has provided the foundation for much of the current knowledge of sea turtle biology and nesting ecology and has served as an example of a classic conservation success story. Tortuguero hosts the largest nesting population of green turtles (*Chelonia mydas*) in the Western Hemisphere, and globally remains one of the most important nesting sites for this species. In addition, leatherback turtles (*Dermochelys coriacea*) nesting at Tortuguero form part of the fourth largest nesting population of this species in the world, and the beach also supports a small but important population of hawksbill turtles (*Eretmochelys imbricata*). This paper will discuss investigation methods and monitoring protocols, with an examination of their development over the last half-century, and will include results from important historical studies initiated at Tortuguero. From its humble beginnings to modern scientific advances, the research program at Tortuguero is one of the longest running research programs in the world for any species. Findings will be presented from the long-term tagging program, which includes over 50,000 individuals, and continues today. These tag return data provided the first irrefutable proof that green turtles were migrating throughout the Caribbean but returning to Tortuguero to nest; subsequent technological advances have revealed the details of these extensive migrations. Population trends observed over the last three decades will be examined, with specific reference to the documented increase of over 400% in green turtle nesting since conservation measures were established. The population status of the three marine turtle species nesting at Tortuguero will be discussed with respect to past, present and future threats. Over the years Tortuguero has served as the testing ground for research methodology that has been incorporated into turtle conservation and monitoring projects around the globe. It has also been a classroom for generations of turtle biologists and conservation managers. The past 50 years have been fraught with difficulties, but there have been many significant accomplishments. While the present is not perfect, and the future promises a new array of challenges, the valuable lessons learned provide hope for the continued survival of sea turtles at Tortuguero.

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## **ENCOURAGING NEWS FROM BUCK ISLAND REEF NATIONAL MONUMENT: STATUS AND TRENDS IN THE NEW MILLENNIUM**

**Zandy Hillis-Starr and Ian F. Lundgren**

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For over 20 years, the Buck Island Sea Turtle Research Project has conducted research and monitoring on threatened and endangered sea turtles in St. Croix, US Virgin Islands. Since 2000, new and encouraging trends have emerged at Buck Island Reef National Monument nesting beach. New species (*Caretta caretta*) have begun to nest, underrepresented species (*Chelonia mydas* and *Dermochelys coriacea*) have increased in numbers, and most dramatically numbers of nesting *Eretmochelys imbricata* have approximately doubled and remained consistent for 3-4 nesting cycles. Management techniques have changed through increased knowledge, experience, and by necessity. Managing twice the number of turtles with the same human and financial resources has fostered new priorities and solutions to challenges. As the U.S. National Park Service looks to streamline research and monitoring activities, new technologies are being integrated, new partnerships are being formed, and more complicated conservation issues are being tackled.

## **SOME AGED FEMALES LACK NESTING EXPERIENCE\***

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Seventy-two female loggerhead turtles, of which 68 were incidentally captured by Japanese coastal fisheries and 4 were washed up on Japanese coast, were examined for standard straight carapace length (SCL) and sexual maturity. Turtles which had corpus luteum and/or corpus albicans were categorized as mature, and turtles which lacked them were categorized as immature. Nineteen were categorized as mature (SCL: 814±47mm) and 53 were categorized as immature (SCL: 731±47mm). Both mature and immature appeared in the size from SCL 732mm to 823mm, and larger ones (>SCL823mm) were all mature. Then, we estimated the age range of 32 turtles by growth rings on their humeri. The age range of mature was 42±11 years (range: 22-61, n=13), and the age of immature was 36±13 years (range: 17-61 years, n=19). It should be noted that the age of some immature were relatively older than mature, and not all aged immature were larger ones in SCL. The SCL of oldest immature (61 years) was 701mm. Although this aging method has not been completely established, it was probable that the age at sexual maturity of female loggerhead turtles was more than 22 years old, but some females do not reach maturity until 40's, 50's or 60's. In addition, the size at sexual maturity was SCL 732mm in minimum and SCL 826mm in maximum. The difference of maturity age and SCL size may depend on nutritional status. Furthermore, we compared appearance season between mature and immature females. Mature females appeared only during the nesting season (April to July), whereas immature females appeared throughout the year. Additionally, all mature females had shelled eggs in their oviducts. This suggests that female loggerhead turtles come over to the Japanese coast to feed and/or migrate until reaching sexual maturity, but after reaching maturity, they depart from the coast until nesting season.

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## **TEMPORAL AND SPATIAL EVALUATION OF NATURAL PREDATION ON THE KEMP'S RIDLEY, AN ARRIBADA SPECIES**

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The Kemp's ridley was near extinction in the mid 1980's and has since been the subject of an intense international conservation effort. In Rancho Nuevo, Mexico, where the majority of nesting occurs, poaching and predation have historically been avoided by relocating nearly all of the nests to protected egg corrals. Because of this and other conservation measures, the number of nesting females has steadily increased for over the past two decades. The gradual increase in the number of nests has necessitated many hundreds of nests being left in situ during recent years. During the 2008 nesting season, a study was conducted to evaluate temporal and spatial aspects of predation on in situ nests. Although the overall amount of nesting in 2008 was relatively high, it was scattered geographically and temporally. As such, relatively large and geographically concentrated arribadas were not present. In order to investigate predation, four subsets of in situ nests, which were spread over 14 km of nesting beach, were examined twice daily throughout their incubation period. This examination included the evaluation of predator tracks and the direct observation of predators using wildlife cameras and night vision equipment. The results indicate that the main nocturnal predators are coyotes, raccoons, and skunks. Additionally, ghost crabs, birds, flies and ants impacted egg/hatchling survival. Predators typically frequented the area around each nest on a daily basis. Some previous studies of sea turtles suggest that nest depredation primarily occurs during the time of laying and hatching. However, during the current study, nest depredation occurred throughout the entire incubation period. Depredation was relatively consistent at all four locations, distributed along the 14 km study area. Finally, nest depredation appeared heavier during the 2008 nesting season in comparison to previous years.

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## PROJECT TO DETERMINE THE DISTRIBUTION AND POPULATION SIZES OF NESTING MARINE TURTLES IN NEW CALEDONIA, AND TO ENHANCE THE CAPACITY OF LOCAL GOVERNMENTS TO PROTECT AND MANAGE THESE SPECIES

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In December 2006 and January 2007, WWF New Caledonia and its local (New Caledonia Government and Provinces) and regional (Queensland Department of Environment) partners carried out the first ever New Caledonia country-wide survey to determine the distribution and population size of nesting marine turtles. A Cessna 206 flying at +/- 100 knots and at approximately +/- 100 feet of altitude surveyed more than 6000 km and 90% of New Caledonia's mainland and island beaches. The flights occurred over a six day period, at a rate of +/- six hours per day, beginning at "first light", and at low tide. Simultaneous to the overflights, some 15 ground truthing teams consisting of approximately 100 individuals (consisting of trained field technicians and local volunteers) surveyed a series of known and suspected turtle nesting sites to record the species type and morphological data of nesting turtles, record or place tags, obtain genetic samples and collect site specific data pertaining to perceivable threats to nesting turtles. The results of the survey confirm the previously identified nesting populations of green turtles, *Chelonia mydas* (several thousand nesting females per year and thus the most important nesting site in the South Pacific Island Nations for this species), and loggerhead turtles, *Caretta caretta* (200 nesting females and thus 20% of South Pacific population for this species). On the other hand, the survey also effectively dispels the some 30 year old theory concerning the existence of a nesting population of hawksbill turtles, *Eretmochelys imbricata*, which was suspected to exist in the Loyalty Island group. Furthermore, this unprecedented field study and "capacity building" exercise has exponentially increased the in-country capacity to study, monitor, and protect nesting turtle populations in what is considered to be the "world's largest lagoon", "world's second longest barrier reef", inscribed on the UNESCO world heritage site in July 2008.

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## SEA TURTLE NEST PREDATION DYNAMICS: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT\*

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The north coast of Bahia (13°00'S-38°27'W – 11°27'S-37°21'W), NE-Brazil, is the main reproductive site for sea turtles in this country, with occurrences of four species *Caretta caretta*, *Eretmochelys imbricata*, *Lepidochelys olivacea* and rarely, *Chelonia mydas*. Around 200 km of beach are fully patrolled and monitored by Projeto TAMAR's staff (Brazilian sea turtle conservation program). Nests are covered with grids to avoid predation and monitored from nesting to hatching. However, even with the use of these grids nests at some beaches are under great pressure of animal predation. We studied the very north of the area (19 km) during 5 nesting seasons (2003-2008) meanwhile management strategies changed. From 2005/2006 season on, nests in this area are protected with the in situ strategy, where nests are left in their original places instead of being relocated to open hatcheries, as done before. As a result, an increment on the order of 20% was observed on predation and non-identified nests rates. Predation events were not related to the number of nests in each monitored km ( $R^2=0.071$ ;  $p>0.05$ ), but are strongly related with the total number of nests in a given period ( $R^2=0.868$ ;  $p<0.05$ ), with greatest predation rate being coincident to the nesting peak, in December. The main predators are wild dogs, *Cerdocyon thous*. During the 2007/2008 season, flags were used to test reduction in nest predation, using three treatments: grid, grid/flag and grid/flag/rattle. A total of 635 nests were recorded, 388 *L. olivacea*, 97 *C. caretta*, 3 *E. imbricata* and 147 non-identified nests. Predation occurred in 145 nests (22.8%), among which 66 (45.5%) were of *L. olivacea* nests (17.0% of the species nests), 65 (44.8%) of non-identified nests (44.2% of the non-identified nests), 13 (8.9%) of *C. caretta* (13.4% of the species nests) and 1 of *E. imbricata* (33.3% of the

species nests). No clear preference was observed between nests of different species. Eighty-eight nests were predated before protection of any kind have been placed (62.1% of the overall predation) and 2 were harvested for human consumption. Among the 545 protected nests 57 (10.5%) were predated, 77.2% of non-flagged nests. Significant difference is observed between predation rates on nests with grids and grid/flag ( $\chi^2=25.98$  d.f.=1  $p<0.001$ ). The same is detected when compared to nests with grid/flag/rattle ( $\chi^2=17.65$  d.f.=1  $p<0.001$ ). Overall, a total of 329 nests were protected with grid/flag and grid/flag/rattle, with no significant difference between these treatments ( $\chi^2=0.11$  d.f.=1  $p>0.05$ ). From these flagged nests, 311 (94.5%) successfully hatched and 13 (3.9%) were predated, showing significant difference regarding nests only protected with grid ( $\chi^2=37.52$  d.f.=1  $p<0.001$ ), representing a reduction above 15% on predation rate. Finally, even taking into account predation rates, in situ strategy produced around 10% more hatchlings than the earlier strategy. We also point out that non-identified nests are mainly due to predation events. Consequently we believe that the use of flags, as well as an improvement on management efforts can result on higher hatch success and also better rates of nest identification. Acknowledgements: We are grateful to Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish, Wildlife Service (Marine Turtle Conservation Fund) and to the International Sea Turtle Symposium for travel grants awarded to G.O.Longo for attending this Symposium.

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## **TOWARD A COMPREHENSIVE MODEL TO MAXIMIZE THE PRODUCTIVITY OF HAWKSBILL NESTING BEACHES: DECIDING WHERE TO RELOCATE IMPERILED NESTS AT BUCK ISLAND REEF NATIONAL MONUMENT**

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Providing *Eretmochelys imbricata* at Buck Island, St. Croix, U.S. Virgin Islands the best chance for recovery includes relocating imperiled nests. Maximizing the productivity of those nests is consistent with the species recovery plan and with the mission of the U.S. National Park Service. By relocating nests into experimental plots that standardize substrate particle size, percent organics, and shading, we investigated how these and other associated variables (water content and potential, salinity, substrate origin, elevation, clutch size, temperature) ultimately affect hatching success measured in two ways: percent of fertilized eggs that hatch and the size of hatchlings. By focusing on variables that are discernible even in darkness, we expect to develop a simple decision tree for field staff that identifies the most optimal locations for relocating imperiled nests. Although we are reporting preliminary findings from ongoing research, ultimately, this information about “where” to move nests coupled with information on “when” (using intra-seasonal and stochastic beach dynamics) to move nests could be used to generate a model that can maximize the fecundity of hawksbill nesting beaches globally.

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## **THE EFFECTS OF COMMON LOGGERHEAD NEST MANAGEMENT METHODS ON NEST SUCCESS ON SAPELO ISLAND, GEORGIA, USA\***

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In Georgia (USA), loggerhead (*Caretta caretta*) nest relocation and predator protection methods vary among the barrier island beaches. Generally, nests laid below the spring tide line are relocated to higher elevations to prevent tidal inundation. Plastic or wire screens are often placed over nests to prevent depredation by mammalian predators such as raccoons and feral hogs. Previous studies report conflicting results of the effects of nest relocation; however, such results are unique to the beach and the sea turtle species being studied. Many of Georgia’s nesting beaches have not

been evaluated with respect to a standardized nest management protocol that maximizes nest success. From 2002-2007, we investigated the effects of nest relocation and screening on loggerhead nest success on Sapelo Island, Georgia. We randomly applied one of five treatments to loggerhead nests (n=381). Treatments were 1) locate egg chamber in-situ, 2) locate egg chamber in-situ with screen placement, 3) relocate eggs without screen placement, 4) relocate eggs with screen placement, and 5) a control (do not locate egg chamber, no relocation or screen placement). Predator activity is relatively low on this island, and was minimal for the duration of the study. Analysis of covariance (ANCOVA) was used to examine treatment effects on both hatching success (the proportion of successfully hatched eggs) and emergence success (the proportion of hatchlings successfully emerging from the egg chamber). Nesting year was included as a block, and nest elevation as a covariate. We found no significant treatment effect on hatching success ( $F(4,367)=2.03$ ;  $p=0.09$ ) when adjusted for elevation. Emergence success showed significant annual variation ( $F(4,367)=2.96$ ;  $p=0.02$ ), although a treatment effect was not detected ( $F(4,367)=1.32$ ;  $p=0.26$ ). Adjusted means of hatch success and emergence success were high across all treatments for all years, ranging from approximately 70-80% hatch success and 66-79% emergence success. In-situ nests (1, 2, 5) yielded the highest mean success rates for both hatching and emergence. Nest elevation strongly affects hatching success and emergence success ( $p<0.0001$ ). The role of nest elevation in determining the “fate” of a nest warrants further investigation. Annual variation in emergence success was possibly influenced by yearly changes in fire ant activity, vegetative growth, and technician error when relocating nests. High nest success rates on Sapelo Island could be maintained through implementation of a less manipulative, more conservative nest relocation strategy. Plastic screens appear to have little detrimental effect on nest success, and should continue to be used as a protective measure. Our results demonstrate the usefulness of evaluating nest management methods. Each Georgia barrier island exhibits unique habitat characteristics - including varying levels of predator activity - that should be independently evaluated in an effort to develop statewide protocols.

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## **LOGGERHEAD AND ATLANTIC GREEN SEA TURTLE NESTING AND HATCHING TRENDS ON EGLIN AIR FORCE BASE, FLORIDA FROM 1995 THROUGH 2008**

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Sea turtle nesting surveys have been conducted on Eglin Air Force Base (AFB) since 1989. Trends concerning nests and hatching success were examined from 1995—2007. Four species of sea turtle are documented to nest on this property: Loggerhead (*Caretta caretta*), Green (*Chelonia mydas*), Leatherback (*Dermochelys coriacea*), and Kemp’s ridley (*Lepidochelys kempii*). Loggerheads had the highest abundance of nests over the 13 years with an average of 16.9 nests per year. Greens only nested on Eglin AFB 8 out of the 13 years, but had the next highest abundance of nests with an average of 9.9 nests per year. Both loggerheads and greens showed a small decline in nests, on average, over the years, which was somewhat different than the state of Florida (as a whole) nesting trends. The state of Florida trends showed a decrease in loggerhead nests over the years, but an increase in green nests. On Eglin property, loggerheads and greens both averaged a 40% hatching success rate over the years (this percentage takes nests washed away by storms into account). Hatching success has increased for both species over the years despite a decline in nest numbers. This suggests that Eglin has improved their surveying efforts in regards to predation, lighting disorientation, and human deterrence.

## **THERMAL MICROENVIRONMENTAL INFLUENCES ON THE CRITICAL INCUBATION TEMPERATURE FOR OLIVE RIDLEY SEA TURTLES AT OSTIONAL, COSTA RICA**

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The Ostional Wildlife Refuge in Costa Rica is host to one of the most important olive ridley (*Lepidochelys olivacea*) nesting rookeries in the Eastern Tropical Pacific. Besides significant solitary nesting, large 2-5 day arribada events occur, growing to peak numbers of over tens of thousands during the heaviest rainy months. Even though Ostional beach measures four kilometers in length, the arribadas are usually concentrated on a main nesting area (MNA) of barely one kilometer of beach. Only during the largest arribadas females are forced to spread out to adjacent beach areas due to spatial constraints. Despite the apparent predator satiation effect inherent to mass nesting, the arribada nesting area typically suffers from low hatching rates most likely due to the high level of intraspecific destruction of nests, leaving the beach with large numbers of decomposing eggs that promote a favorable environment for microorganism growth, thus impacting embryo development and its environment. Despite being exposed to the same predation dynamics, nests deposited away from MNA may be favored to have higher hatching rates because of the wider spatial distribution and thus a lower chance of intraspecific nest destruction and lower contamination levels. Olive ridley nesting occurs year-round. Yet, all nests laid in the dry season are considered lost because the sand reaches temperatures far beyond maximum incubation temperature thresholds. This may explain why the majority of nests are laid during the rainy season. In this context the rain might be regarded as an essential ecological condition to increase hatching chances by lowering sand temperatures below the critical incubation temperature and increasing humidity levels. This could possibly maximize the hatching rates for areas away from MNA and even the smaller arribada events earlier in the rainy season. In contrast, the extreme nest density and contamination levels during the peak arribadas could cause the sand temperature to increase, despite the rainfall, and distort embryo development. Our research is aimed at investigating differences in sand temperature between the MNA and the rest of the beach during the peak arribada months. We wish to test the hypothesis that under the same rainy circumstances the thermal microenvironment of the areas away from MNA are significantly lower, thus facilitating a more suitable window below the critical incubation temperature and increasing the chance of higher hatching success. We will follow the daily precipitation levels for Ostional beach as well as the incubation temperatures of random nests throughout the beach in the months of September, October and November. Nests will be marked and supplied with dataloggers designed to record incubation temperature. After the incubation period the nests will be exhumed for nest fate, egg composition and hatching success. Additionally, the dataloggers will be processed and incubation temperatures analyzed and correlated with the precipitation levels. If our hypothesis holds this could imply recommendations for the increased protection of solitary nests, as well as the increased protection for the smaller arribadas early in the rainy season since they may play an important role in supporting recruitment to the adult Ostional population.

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## **THE USE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR THE SUPPORT OF THE MARINE TURTLE RESEARCH AND CONSERVATION IN SOYO, NORTHERN ANGOLA**

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The Wildlife Conservation Society Conservation and Research Program (WCS) has joined Angola LNG (Angola Liquefied Natural Gas) in a partnership aimed at research and conservation of marine turtles in the Soyo region of

northern Angola. The GIS component covers 20 km of nesting beaches (15 km on the Sereia Peninsula - western coast of Soyo, Atlantic Ocean; and 5 km in Kwanda Island - northern coast of Soyo, Congo River), and provides management support, mapping, and spatial and temporal analysis of Sereia Turtle Project data and aerial imagery. The Sereia GIS component is an ESRI ArcMap project connected to an Access database which is easily accessible. Data is collected and for each occurrence, the GPS position is taken and recorded on a simple field unit, and then processed into data sheets and Access forms. Tables and queries are linked to ArcMap features, and the resulting data are then overlaid on a satellite image or map to show the geographic distribution of the queries, as well as to build geographic queries directly into the GIS project. Geographic indices of nest intensity are calculated and shown as a nest density map of nests per kilometer identifying peak areas of nesting; other marine and beach data related with the Sereia Peninsula are also added to the system. This allows us to monitor and analyze change over time relating to these processes, to identify habitats suitable for sea turtle nesting, and to predict changes to habitat and, consequently changes in nesting density. Exploring these system-wide sets of data effectively is essential in successful ecosystem management.

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## **METAPOPULATION THEORY AND SEA TURTLES: BRIDGING OR WIDENING THE GAP?\***

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Scientists have not yet fully developed marine metapopulation theory, or established how metapopulation dynamics can be used in conservation, such as in marine reserves. Even less information is available in the literature about the application of metapopulation theory in sea turtle ecology. The main difficulty in applying metapopulation concepts to sea turtles is the ambiguity of the various definitions of “metapopulation,” clouding understanding of the theory itself, if it is appropriate to use to describe sea turtle populations, and if so, which ones. This paper examines metapopulation dynamics and its current application in sea turtle ecology, specifically two empirical examples using markedly different definitions: the North Atlantic loggerhead sea turtle (*Caretta caretta*) metapopulation that is described as genetically distinct subpopulations that exhibit connectivity; and the Great Barrier Reef green sea turtle (*Chelonia mydas*) metapopulation described as one genetically homogenous population broken up into subpopulations that utilize spatially disjunct foraging habitats. This literature review concludes that metapopulation concepts in sea turtle ecology are not clear, nor are they currently universally applied in a consistent manner. Utilizing metapopulation theory at the wrong spatial scale (local, regional), or under incorrect assumptions (connectivity, ecological constraints) is not useful. We argue that metapopulation theory cannot be applied to all sea turtle populations, and to those population where it is appropriate, it cannot be applied uniformly. More research and development of metapopulation theory must be completed before this concept can be universally applied to sea turtles. Understanding population dynamics of sea turtles, including how they dynamically utilize patchy habitat, is essential to sound conservation decision-making. We thus need to better define and develop, both qualitatively and quantitatively, the metapopulation concept for application to sea turtle population ecological theory.

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## **EFFECT OF STORM FREQUENCY ON THE LEATHERBACK HATCHING SUCCESS**

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The eggs of the sea turtles depend on the environmental conditions of beaches for their incubation. The sand moisture is a determining factor in the hatching success that each nest experiences at a certain time. As a consequence of global warming, the much predicted sea level rise and associated high frequency of tropical storms can alter the hydration conditions of nesting beaches of sea turtles. We studied the vulnerability of leatherback turtle embryo to different sand

moisture conditions. An experimental factorial design 3\*2 was done considering three different levels of embryonic development: (first second and last third of incubation) and two different inundation scenarios (a total eight days of inundation for both scenarios, 15% water in sand, gravimetric), but the first inundation scenario was alternated 2 days dry (1% water in sand, gravimetric) and 2 days inundated, while second inundation scenario was eight continuous days inundated. Control condition had no inundation. Four eggs from five different females were pooled in each treatment, with one egg per experimental plastic box. The incubation was at 60 cm depth in an open beach hatchery. Our results highlight that embryonic development is specially sensitive to inundation in the first third of incubation, however the lethal effect is noticeable with 8 continuous days of inundation (Chi-square = 9.66, p = 0.001). Hatching success in control treatment (82.3%) was higher than natural nests (typically 40-50%). Leatherback eggs can tolerate the first inundation scenario, with dry periods between inundations (hatching success in first third = 58.8%, second third = 58.8% and third third = 64.7%). Thus our results show that it is highly likely, that high frequency of tropical storms or continuous high moisture in sand levels as global warming consequences, will affect the reproductive success of leatherback turtles.

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## HUNTING HATCHLINGS: ASSESSING LOGGERHEAD HATCHLING EMERGENCE AND PREDATION RATES AT A DENSELY NESTED LOGGERHEAD BEACH

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Predation of sea turtle hatchlings following emergence from nests is a worldwide phenomenon. Zakynthos is the largest known nesting area for loggerhead turtles (*Caretta caretta*) in the Mediterranean, and since 2000 has been protected within the framework of the National Marine Park of Zakynthos (NMPZ). In the NMPZ breeding-area, Sekania beach holds approximately 53% (n=668) of nests, with records of yellow-legged gull predation (*Larus cachinnans michahellis*) dating back to the onset of monitoring. In recent years gull numbers have increased; hence an assessment of the impact of gulls on hatchling survival-rates was deemed necessary to determine appropriate predator management actions. The NMPZ Management Agency in collaboration with ARCHELON and the Hellenic Ornithological Society conducted intensive surveys to determine (i) 24-hour hatchling emergence-rates (ii) gull predation-rates. Hatchling emergence-rates were assessed through trapping and counting hatchlings along an 80m section of beach in nine survey days during the 20-day peak hatching-period (16/08/2008-03/09/2008). Gull activity and predation-rates were assessed throughout the hatching period (06/08/2008-12/9/2008) via six three-day morning (06:00-10:00), four three-day surveys (06:00-20:00) and two night surveys (20:00-06:00) using binoculars and telescopes. Nest hatching information was collected by NMPZ researchers and ARCHELON personnel. Gulls frequented Sekania beach during daylight hours only, i.e. between 06:00 and 20:15, peaking at 07:15-08:30 (peak mean = 130.3 range 10-280) and 13:30-19:30 (peak mean=279, range 210-350). Hatchling emergence rates between 06:00 and 20:30 were 19.5% (n=91, total n=466; sd±6.3), of which 7.5% (n=7) were too weak to reach the sea. Between 06:00-10:00 (i) 72% (n=69, total n=96) of hatchlings were recorded during the emergence study, and (ii) 92.6% (n=176, total n=190) of hatchling predation by gulls was observed in the predation study. On average 45% and 55% of possible and/or definite hatchling predation-rate was beach-based and nearshore (<300m from shore) before 10am, while after 10am it was 83% and 17% respectively. A mean 28 hatchlings were subject to possible/definite predation per day on the beach and/or nearshore area during the core hatching period (i.e. when 3 or more new and/or old nests hatched per day; 24/7-14/9), which represented a 4.7% overall predation rate (assuming 108 eggs/nest and 68% hatchling emergence rate). Potentially up to 20% of hatchlings emerging at Sekania could be subject to predation, however at present combined beach and nearshore predation levels are below 10% (tolerable limit by the Florida Fish and Wildlife Conservation Commission 2002) and predation at other beaches in the rookery is negligible. However, continued monitoring is required to detect and implement an adequate management response in the event of increased predation levels at Sekania, which may negatively impact future population parameters.

## ACTIVE MANAGEMENT

**Laurent Sourbes, Gail Schofield, Kostas A. Katselidis, and Amalia D. Karagouni**

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Conservation management of protected areas is a continuous process requiring information flow between managers, scientists and field personnel. Standard guidelines and criteria based on sound scientific research are essential to decide when and why to invoke one management option over another, how to effectively implement the chosen option, and how to evaluate success. The National Marine Park of Zakynthos (NMPZ) was formed in 2000 with the responsibility to safeguard the endangered loggerhead turtle (*Caretta caretta*) breeding area in Laganas Bay. Since formation, the 24 hour NMPZ guarding programme has been in place on the six nesting beaches (totalling 5.5km) comprising an average estimated nesting effort of 1245 nests annually (1994-2007 dataset; SD± 302; range: 833-2018). The guards are essential as Zakynthos is frequented by over 700,000 visitors each summer, many of whom seek out the sandy nesting beaches in Laganas Bay. Due to legislation being precautionary-based, in 2007 the NMPZ initiated a scientific programme to obtain standardised information on a range of sea turtle, environmental and anthropogenic parameters to improve long-term protection management of the nesting beaches. However, immediate information provision was also required in the proximate year. Therefore in 2008 the NMPZ Management Agency set out to integrate the scientific and guarding programmes through frequent data assimilation and strengthened communication, whereby potential problems were identified, assessed and addressed week by week. Within the volume of information collected by the NMPZ scientific research team, the tool with most utility for providing an immediate and visual source to identify areas in need of increased protection is GPS technology. Handheld GPS-units (Trimble and Garmin) are used by the NMPZ research team to record a range of parameters including: (1) beach-structure, (2) daily laid and hatched nest locations (3) official permitted sun-umbrellas and furniture zone (4) weekly 'peak' beach visitor distribution (i.e. Saturday-Sunday, 14:00-16:00). The NMPZ research team assimilated these four parameters each week on Excel datasheets and GIS-based maps. The maps were given to the NMPZ managers and guarding programme within the framework of a weekly report. This provided a tool whereby nest locations (particularly nests that were not caged) and key problem sites where visitor distribution overlapped with nest locations were indicated helping to improve beach-based management techniques. The production of weekly GPS maps ensured the work of the NMPZ research team directly aided and complemented the NMPZ guarding programme ensuring the nests were adequately protected, while providing NMPZ managers with a reliable data source from which to develop within season management activities and receive feedback on effectiveness.

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## TOO MANY HOT GIRLS IN PAPUA NEW GUINEA - ESTIMATING SEX RATIOS OF LEATHERBACK TURTLES

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This study investigated the estimation of the sex ratio of leatherback turtle hatchlings at the Huon Coast, Papua New Guinea, during the nesting season 2006/2007. The evaluation is based on temperature-dependent sexual determination with females being produced at higher incubation temperatures. In leatherback turtles an incubation temperature of approximately 29.5 °C produces a 1:1 ratio of male to female hatchlings. The temperature dependent sex determination of leatherback turtle hatchlings based on a mean incubation period of 58.96 days was estimated to be 100 % females for the season 2006/2007. The suspected decline of the leatherback population at the Huon Coast in conjunction with the highly biased sex ratio towards females leads to severe concern about the survival of this heavily depleted stock. Therefore, without the sustainability of long-term conservation activities for this important nesting population as part of the meta-population in the western Pacific it has to be presumed that they face the same overall decline as leatherback populations in the Indian Ocean and other regions of the Pacific Ocean.

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## **POST-TSUNAMI LEATHERBACK NESTING IN SOUTH BAY, LITTLE ANDAMANS**

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The Andaman and Nicobar islands have the best nesting beaches for leatherback turtles in the northern Indian Ocean region. These islands, particularly the Nicobar group, lie closest to the epi-center of the earthquake that triggered the recent tsunami. The coastline and the shore topography has been severely altered in many of these islands, with many beaches in the Nicobar group undergoing submergence, while the coastal plates in some of the Andaman islands have been uplifted. The consequent impact of these physical changes to the nesting beaches for leatherbacks still needs to be fully understood. Prior to the tsunami, leatherback turtles nested in large numbers (> 1000 nests per year) at several beaches in the Nicobar islands, but many of these beaches were destroyed by the tsunami. Nesting was also reported along the West Bay and South Bay of Little Andaman Islands. The current study was undertaken to investigate nesting at these sites. The nesting beach of South Bay was monitored for a period of three months (January-March, 2008) for leatherback turtle nesting. 41 nests were encountered and 9 nesting females were observed. Nest depredation by monitor lizards was found to be very high. Annual monitoring is planned at both beaches in Little Andamans to assess population status and trends.

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## **EVALUATION OF NEST PREDATION ON OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) AND GREEN TURTLE (*CHELONIA MYDAS*) ALONG THE INDEX BEACHES OF GUJARAT-INDIA: SIGNIFICANCE OF STAKEHOLDERS INVOLVEMENT**

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Status of nesting population and predation pressure was studied along the 17 index beaches on the Gujarat coast, India, in the years 2000-01 and 2004-05. The first survey, which was one time, was carried out only by the project personal while, during 2004-05 eight and nine index beaches were monitored every month by the project personal (PP) and local villagers (LV) respectively. Nest predation pressure was compared between the species, years and among the beaches that were monitored by the PP and LV to understand the involvement of local community and the level of significance and validity. During 2000-01 survey, 416 nests were counted, of which 67% (277 nests) belong to the green turtle while 33% (139 nests) were laid by the olive ridley. Out of 416 nests enumerated 59 % (246 nests) of nests were found predated. Species-specific predation showed that olive ridley nests were under more predation (68%) compared to green turtle (55%), which resulted in a difference of 13%. Monthly monitoring in 2004-05 enumerated 1902 nests with the species composition of 65% (1234 nests) green turtle and 35% (668 nests) olive ridley. Monitoring survey estimated 838 (44%) nests were predated that was 15% lower than the one time survey. Species-specific predation showed the same trend with more olive ridley nests (52%) being predated than green nests (40%). One time survey estimated more animal predation (35%) than human (25%), whereas, long-term monitoring resulted comparatively low predation on both the cases (animal 28% and human 17 %). Comparison of nest predation levels among the beaches revealed that, for eight beaches monitored by PP ranged between 38 and 61% with overall 52%, for the nine beaches monitored by the LV reported variation of 31-44% and overall of 38% with the difference of 14%. Status of predation sources revealed, beaches monitored by the LV were subjected to lower human predation (27%) than the beaches surveyed by PP personal (47%). Frequent monitoring of nesting beaches with the involvement of local villagers can reduce the overall predation and specifically restrict the people involved in egg poaching. Further, nest relocation from the beaches under high animal predation will ensure conservation and long term survival of sea turtles along the Gujarat Coast.

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**HABITAT AND NEST DISTRIBUTION OF HAWKSBILL TURTLE  
(*ERETMOCHELYS IMBRICATA*, LINNAEUS 1758) CASE STUDY : BURUNG  
ISLAND OF KARIMUNJAWA ISLANDS, CENTRAL JAVA, 2005**

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The characteristics of hawksbill turtle nesting habitats varies in terms of beach slope, beach length-width, sand grain size composition and vegetation, also in nest distribution. By studying former research, it suggested that different physical characteristics of hawksbill nesting beach in Indonesia showed different number of nests and distribution pattern. To investigate the specific characteristics of Burung Island nesting habitats, we divided the beach into plots of 200 meters, with two substations in each plot. Parameters measured were beach slope, beach length, beach width, distance of nest sample to outer vegetation and tide, nest substrate temperature, air temperature, humidity, sand grain size and beach vegetation. Secondary data included climate data of the year of investigation (2005), tidal range and hawksbill nest. Hawksbill nest distribution was limited to the south and south west part of Burung Island. Overall, we observed three old nests and two potential nesting spots. Total beach length of Burung Island was 556 meters but only 286 meters had potential for nesting due to the narrow beach and beach slope. The sand grain size was dominated by coarse and medium sand. According to hawksbill nesting preferences, Burung Island has relatively good potential for nesting sites. However, this small island is unstable and at risk to habitat degradation. Principle Component Analysis (PCA) indicates that nest distribution is best explained by distance of nest sample to outer vegetation, and substrate parameters (coarse sand, medium sand and dust). Vegetation (*Tespesia* sp.) has the highest Important Value Index. Compared to other regions, the physical characteristics of Burung Island resemble nesting sites in Seribu Islands such as Peteloran Barat Island, Peteloran Timur Island, Gosong Rengat Island, Kotok Kecil Island, Dapur Island, Sepa Barat Island, and Gosong Sepa Island.

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**NESTING AND INCUBATION CHARACTERISTICS OF THE INDONESIAN  
HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) AT SEGAMA  
ISLANDS IN THE JAVA SEA FOR 10 YEARS OF RESEARCH**

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The Segama Islands are located in the western part of the Java Sea and 130km north-west from Jakarta and are comprised of Segama Besar Is. and Segama Kecil Is. The distance between Segama Besar Is. and Segama Kecil Is. is approximately 1km. Most nesting activity is from hawksbill turtles. We had surveyed three times at these islands in 1995, 1996 and 1997, before we started conservation activities for hawksbill turtles there. We primarily estimated the hawksbill turtle nesting levels at roughly 200 nests a year around these two islands. All nests were poached by local people for selling to the fish markets and as their own food before our activities started. We have employed four local people as guardians for the nests. Monitoring started at Segama Besar Is. in December 1997 and at Segama Kecil Is. in 2005. The nests at Segama Kecil Is. have been relocated to Segama Besar Is. Nest numbers remained stable from 1998 to 2003, but dramatically increased since 2003. Main nesting peak is usually seen from February to March every year and a second nesting peak was seen in August, 2003 and 2005. However, any changes were not seen in other years. The Beach at Segama Besar Is. is separated into four zones, A; north-east, B; south-east, C; south-west and D; north-west. The location of hawksbill nesting activity has varied with both seasonal and year-on-year changes observed. Nesting activity in zone C was finally predominant containing more than 60% of activity in 2007. We researched hatching success through the year by surveying from 72.6% to 95.7% of all the nests. The hatching success ranged from 51.8% in 2002 to 67.2% in 2001. Low hatching success was a result of ant predation on the eggs. The percentage of predation is approximately 20% every year.

## **NESTING REPORT OF BLACK SEA TURTLE (*CHELONIA MYDAS AGASSIZII*) IN BAJA CALIFORNIA SUR, MEXICO**

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In Baja California Sur, Mexico, five of the seven species of marine turtles of the world are found. However, only two of them are reported to nest there those being: the leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*), and the remaining; hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and black turtle (*Chelonia mydas agassizii*) have only been reported in feeding zones. In 2002, black turtle hatchlings were born in a marine turtle nursery operated by the Marine Turtle Protection Program of H. Ayuntamiento of Los Cabos, B.C.S. which was the first official reported nesting of black turtles (*Chelonia mydas agassizii*) in Baja California Sur. Later, in 2003, a new clutch was born, a rare and extraordinary event. There was not an opportunity to observe the nesting female during either of these events. From 2002 to 2007, 8 nests have been reported, and we had the opportunity to observe one of these events during night patrolling. These events confirm that black turtle nesting exists in this zone, and that though it is considered rare, in the past it could have been normal occurrence. Furthermore, it could be that the protection programs in different parts of the country have resulted in the return of nesting green turtles to this beach.

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## **CRIMINAL SCENE INVESTIGATION ON A LOGGERHEAD TURTLE NESTING BEACH: WHO ATE THE EGGS?**

**Sabrina Trocini<sup>1</sup>, Ian Robertson<sup>1</sup>, and Stuart Bradley<sup>2</sup>**

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Nest predation by introduced European red foxes (*Vulpes vulpes*) has been identified as a key threatening process for endangered turtle populations in Australia. In fact, it has been suggested that ongoing nest predation by feral foxes may have contributed to the decline of Western Australian mainland nesting populations, as indicated also by anecdotal evidence of fox predation on turtle nests and hatchlings in Coral Bay in the early 1990's. This study aims to improve the understanding of factors affecting hatching success and in particular, assess levels of predation and predator dynamics at the mainland loggerhead turtle (*Caretta caretta*) nesting beach in Cape Range National Park, to enable informed decisions to be made with regards to prioritising management actions. The research was conducted for two nesting seasons (2006/07 and 2007/08) and results show that predation by ghost crabs (*Ocypode* spp), varanid lizards (*Varanus giganteus*) and feral European red foxes considerably reduce survivorship from egg to hatchling. In fact, in the first and second years of this study, 78.2% and 83.3% of the monitored nests respectively, showed signs of partial or complete nest predation. Ghost crabs were responsible for the majority of recorded predations. Besides, ghost crabs showed to predate on turtle nests at any stage of incubation. In general, ghost crabs tend to burrow into nests earlier during the incubation period compared to foxes and varanid lizards. Ghost crabs are natural predators; however numbers of ghost crabs could have increased above normal levels due to tourism activities. Foxes tend to explore nests for several days and predate on the nest toward the end of incubation. Similarly, varanid lizards tend to predate on nests later during incubation, but do not visit the nest more than two times before predation. Further investigations will be necessary in the future to assess fox control strategies at nesting beaches and to investigate if ghost crab numbers are increased due to anthropogenic factors. Acknowledgements: We gratefully acknowledge financial support for this project from DEC, Murdoch University, BHP Billiton and the Hermon Slade Foundation, as well as travel support from the International Sea Turtle Symposium and all donors.

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## **EIGHT NESTS RECORDED FOR A LOGGERHEAD TURTLE WITHIN A SEASON**

**Anton D. Tucker**

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A loggerhead rookery on Casey Key, Florida hosted a clutch frequency study during 2006-2008. Females were approached after nesting for attachment of satellite tags. Clutch frequency and site fidelity were derived from characteristics of the tracking history. Location data were processed in STAT to omit location classes B and Z and to filter locations for topography > 0.5m, speed > 4 km/hr, locations < 4hr apart, or for azimuth angles < 15 degrees. Multiple criteria were matched to each presumed emergence: (1) emergences within the expected remigration intervals for loggerheads (9-15d), (2) emergence locations associated with depths of -0.5 to 0.5, (3) when movements were directed onshore followed by an immediate offshore vector, (4) improvements in location classes such as multiple LC 2 or 3 within a short time span, (5) evidence of an increased surface interval in the transmitter data, (6) verification by nocturnal patrols if the female was re-encountered, or (7) verification by genetic matching of nest contents. The present study established a new maximum clutch frequency of eight nests for loggerhead turtles. Site fidelity for the eight nests encompassed three adjacent beaches and over 15.9 km between the most distant nests. Those engaged in sea turtle tracking have sometimes expressed skepticism as to whether the uncertainly errors inherent in ARGOS satellite tracking (contrasted with the higher frequency and accuracy of locations with GPS tags) could allow locations to be recorded with sufficient accuracy to document nesting emergences. This study demonstrates that a rigorous data filtering and multiple criteria matching can afford reliability in detecting loggerhead emergences, whether nesting or false crawls, provided that individual turtles display a distinctive pattern of inshore-offshore directed movements. Related studies with other turtle species are required to more extensively test this method of estimating clutch frequency. This research was supported by the Florida Sea Turtle License Plate Grant Program.

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## **GLOBAL ESTIMATE OF ARRIBADA OLIVE RIDLEY SEA TURTLES\***

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The olive ridley (*Lepidochelys olivacea*) is believed to be the most abundant sea turtle species in the world. This is due chiefly to the large nesting aggregations known as arribadas in which these reptiles participate and to their numerous solitary nesting that extend throughout its distribution range, which includes most beaches around the Tropics. Although determining relative abundance of nesting females can be achieved with relative ease on most beaches by traditional track-counting methodology, generating accurate values for arribada beaches has shown to be more challenging given the large number of nesting individuals. Tracking abundance information is a valuable tool for management and conservation since it allows the evaluation of the relative health of a particular rookery. For the past three years we have been collecting information on the nesting ecology of the olive ridley using strip transect methodology at the largest arribada beaches around the globe. The strip transect in time method is an unbiased and statistically robust procedure to estimate the number of females that participate in the massive arribadas. Consistent application of this method has allowed us to generate directly comparable estimates of arribada sea turtle abundance at the various rookeries. Our data indicate that La Escobilla Beach in Mexico is the largest assemblage in the world, followed by Ostional Beach in Costa Rica and Gahirmatha and Rushikulya Beaches in India. This presentation will discuss trends in the interannual abundance of the individual rookeries as well as ecological aspects that may influence such trends.

## **TEN YEARS OF LEATHERBACK NEST SURVEY DATA ON ARUBA 1999-2008**

**Richard W. van der Wal<sup>1</sup>, Edith S. van der Wal<sup>1</sup>, and Sietske M. van der Wal<sup>2</sup>**

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In 1993, when the Sea Turtle Recovery Action Plan for Aruba was published, the total nest number was estimated to be very low. Four species were mentioned as possible nesters. The leatherback was believed to be the most frequent visitor, but real data were lacking. A tight monitoring program for Eagle Beach has been executed since 1999. Eagle Beach is a 2700m long, white sandy beach, a favorite hangout for tourists and locals alike. Artificial lighting is the major threat. The method of surveying, in situ protection and data collection are described and the results presented. The annual nest number has increased from zero (1999 and 2000) to 72 (2008). The average clutch frequency is 8 nests per female and the hatch rate 67%.

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## **SEA TURTLE NESTING AND THE FLOW OF NUTRIENTS IN THE BEACH ECOSYSTEM**

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Archie Carr Center for Sea Turtle Research and Department of Zoology, University of Florida, USA

Investigation of food webs and trophic level transfer of nutrients can be used to delineate the flow of materials and nutrients through ecosystems. Allochthonous or externally-derived input is important to many nutrient-poor ecosystems, especially between marine and terrestrial environments, where marine organisms can act as biogeochemical transporters. Nutrient transport can be traced with stable isotope analysis, which can aid in determining the source and transfer of nutrients, as food web isotopic signatures are reflected in the tissues of organisms. Loggerhead turtles (*Caretta caretta*) traveling from distant foraging grounds make substantial nitrogen, phosphorus, and organic matter contributions to the nutrient-poor nesting beaches in Florida. Stable isotope analysis and measurements of total nitrogen indicate increased nutrient availability from sea turtle nests. However, the influence of green turtle nutrient input on a high nesting density beach has not been measured previously. The purpose of this study was to investigate the role of the green turtle in the terrestrial beach ecosystem and whether the species acts as a vector of nutrient transfer. More specifically, we evaluated the flow of marine-derived nutrients from green turtle nests through the soil and vegetation at Tortuguero, Costa Rica. Sand samples and leaves from five common plant species were collected over a gradient of nest density along the beach. Total nitrogen content and  $\delta^{15}N$  ratios were measured using an elemental analyzer coupled to an Isotope Ratio Mass Spectrometer. We present a pattern of nutrient availability in the sand and assimilation of nitrogen by vegetation with a corresponding pattern of nesting density.

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## **EVALUATION OF HABANERO PEPPER POWDER AS A DETERRENT AGAINST MAMMALIAN PREDATORS**

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We investigated the use of pepper powder as an anti-predator protective measure in a comparative field study. This study was conducted on loggerhead nesting beaches with historically high depredation levels (yearly depredation

average= 30%), especially from raccoons, coyotes and armadillos. All verified and non-relocated nests were given one of five treatments in randomized order intended to deter an initial visit by a mammalian predator. Treatments consisted of traditional protection measures (box cage and screen), pepper, a mixed treatment of screen and pepper (known as pepperscreen) or given no treatment at all. Red savina habanero pepper powder was purchased in bulk and applied to all pepper and pepperscreen nests in equal amounts on a predetermined schedule. Preliminary results indicate that habanero pepper powder can be used as a mammalian predator deterrent with due attention given to re-application after severe rainstorms. This finding can be especially helpful for projects that have remote beaches or projects with few beach accesses or vehicles required to transport large amounts of materials needed to make cages or screens. Further studies can help determine if this pepper treatment acts as simply a deterrent or could be used as a counter measure to predators that display learned behaviors of targeting marked sea turtle nests.

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## **SURVEY EFFORT: WHAT ARE WE REALLY MISSING WHEN WE MISS TURTLES ON THE NESTING BEACH?\***

**Andrea U. Whiting<sup>1</sup>, Colin J. Limpus<sup>2</sup>, and Milani Chaloupka<sup>3</sup>**

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Surveys of nesting turtles are unquestionably the most commonly used survey technique to assess population abundance and detect trends for sea turtle populations. However, despite their frequency there has been a scarcity in the literature regarding survey design and partial season monitoring. We explore the accuracy in assessing population function from different survey techniques for monitoring nesting turtle populations from saturation surveys to regular, but less intensive surveys. Population function is explored through annual nesting abundance estimates, total breeding female abundance estimates, and the ability to detect trends in population abundance. The use of environmental and biological predictors to increase the accuracy and precision of estimates is explored using cross-correlation functions and seasonal and trend decomposition analyses. We use real case examples from long-term data for green, loggerhead and flatback turtle populations to model case scenarios with different sampling regimes. Error in abundance estimates is explored for: a) short and long season nesting seasons, b) low and high density nesting, c) low and high nightly fluctuations in nesting abundance, d) track count and tagging surveys and e) three species of nesting turtles. This study found high variability in error dependent on the population dynamics present on the nesting beach and highlights important apriori information needed to design monitoring regimes producing abundance estimates with an identified error. This presentation highlights the limitations and accuracies of different survey approaches, as well as the differences between species and rookeries.

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## **THERMAL VARIATION IN LEATHERBACK NESTS IN PACUARE RESERVE, COSTA RICA**

**Rebecca A. Xiques<sup>1</sup>, Eric Koepfler<sup>1</sup>, Scott Handy<sup>2</sup>, Sarah Lucas<sup>2</sup>, and David Melero<sup>2</sup>**

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Pacuare Reserve in Costa Rica is one of the most important nesting beaches on the Atlantic for leatherback turtles. Determining the nest temperature microclimate and factors influencing this characteristic were the goal of a study completed in 2008. Vertical temperature profiles from the top, middle, and bottom of clutches of 25 leatherback nests were obtained using Log-tag temperature data-loggers. An additional logger was placed in the sand one meter from the nest at mid-clutch depth to determine the effects of metabolic heating. Most studies have examined nest temperatures by placing a single temperature logger in the center of the nest, but this study suggests that although there may be significant thermal variability between nest regions at key incubation periods that the mid-third temperatures are very similar. Preliminary results indicate that the temperatures within clutches would favor a female skewed hatching

population (temp. average of 30.6, 30.6, and 30.5 °C for top, middle and bottom clutch areas respectively). Metabolic heat generation appeared to be very important and resulted in rank order shifts of highest logger temperatures from surface to mid and bottom logger positions later in the incubation cycle. Comparison to non-nest loggers at mid-depth also revealed strong changes in thermal characteristics, from sand being a heat source in the first half of incubations to sand being a sink in the later half. Preliminary analysis of meteorological variables (air temperature, precipitation, wind speed and direction, solar radiation), show them to be much less important than incubation day in determining nest temperatures. Remaining analysis will examine the role of turtle specific (clutch egg number, hatching success), meteorological, and sedimentary factors contributing to nest variability in temperature microclimate.

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## **GREEN TURTLES OF THE EAST PACIFIC: HOW IMPORTANT ARE THE GALAPAGOS ISLANDS?\***

**Patricia M. Zárate<sup>1,2</sup>, Karen A. Bjorndal<sup>1</sup>, and Alan B. Bolten<sup>1</sup>**

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Main nesting rookeries for green turtles, *Chelonia mydas*, in the Pacific Ocean are located in Australia (Heron and Raine Island), Ecuador (Galapagos Archipelago), Mexico (Colola, Michoacán), and the United States (Hawaii). Historically, in the eastern Pacific Ocean, Colola beach at Michoacan, Mexico, was considered the most important nesting rookery for the species. However, because of a drastic decline in the number of nesting females observed during the last 30 years in Colola, as a result of harvest of eggs, the largest nesting congregation in the East Pacific is now in the Galapagos Archipelago. In order to illustrate the importance of the Galapagos Archipelago to the total green turtle population in the eastern Pacific Ocean, we present past and current annual abundances of nesting females, linkages between foraging areas and the Galapagos stock, and a brief summary of threats facing turtles in the region. Information from previous studies (1970 – 1983) has been summarized and presented along with results from a more recent monitoring program of tagging and nest counts, carried out at the most important nesting beaches from 2002 to 2008. Annual average values of nesting females has not suffered dramatic changes from past to present, as threats are being kept under control by the Galapagos National Park Management. Long distance movements of green turtles tagged in the islands have been confirmed. Tag returns from 1970 to 1979 and 2005 revealed that individuals tagged at nesting beaches and mating areas in the Galapagos Archipelago, traveled outside the Marine Reserve to Panama, Costa Rica, Colombia, Ecuador, and Peru. Satellite transmitters installed on post-nesting females (2003 and 2005) showed movements towards Nicaragua, Costa Rica, and Panama. Some of these returns resulted from turtles being killed for food by locals and by artisanal and industrial fishermen. It has also been reported that green turtles found on foraging areas along the coast of Chile are from the Galapagos nesting stocks based on mtDNA analyses. These results confirm dispersal and migration patterns of Galapagos stock to continental foraging areas along the Central and South American coast.

## **BYCATCH AND OTHER MORTALITY**

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### **DISTRIBUTIONS OF INJURED LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN THE SOUTHEASTERN UNITED STATES: A 9-YEAR REGIONAL STUDY**

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Satellite telemetry studies conducted with both juvenile and adult loggerheads in the southeastern United States (SE USA) demonstrate extended residence of tagged turtles within 20km of coastlines between spring and fall. As such, loggerhead foraging habitats overlap considerably with anthropogenic activities, increasing the probability for negative interactions between sea turtles and humans in those areas. Although recent data suggest that loggerhead catch rates in SE USA are increasing annually, impaired health of individuals may reduce the future reproductive viability of the predominantly immature loggerheads for which catch rates are increasing. This study reports on the occurrence and extent of injuries exhibited by loggerheads captured during trawling activities conducted by the South Carolina Department of Natural Resources and the University of Georgia Marine Extension Service since 2000. In-water collections of loggerheads occurring during both a randomized regional trawl survey in coastal waters between Winyah Bay, SC and St. Augustine, FL (2000-2003; 2008) and in selected shipping channels (Charleston, SC: 2004-2007; Port Canaveral, FL: 2006-2007). Standardized injury classifications were made while examining sea turtles collected in 2008, but retro-actively assigned using photographs for loggerheads collected between 2000 and 2007. Injury notation included characterization of injury type (amputation/bite/cut); relative injury age; quantitative measurements of injury dimensions; and attributed sources of injuries (when possible to determine). Between 2000 and 2009, 1,440 loggerhead turtles were captured. Of 1,026 loggerheads collected in coastal waters, 321 (28%) were observed with injuries. Of 219 loggerheads collected in the Charleston channel and 77 loggerheads collected in the Canaveral channel, 85 (39%) and 37 (48%) were observed with injuries, respectively. Most of the observed injuries, particularly dominated by non-distinct amputations, could not be attributed to a definitive source. This was largely due to the high abundance of fully healed injuries (73-80% across sampling areas). Among injuries for which source could be attributed, lacerations and cracks from boat propeller interactions were the most common, while definitive shark-related injuries were the least common. With the exception of the Port Canaveral shipping entrance channel, spatial distribution of injured turtles was similar to non-injured turtles. Greatest differences in the proportion of injured versus non-injured turtles collected during regional sampling were noted in 2000 (13%) and 2008 (23%) relative to 2001-2003 (33-35%). The frequency of occurrence and wide geographic distribution of boat-related injuries documented during nine years of in-water data collection illustrates the importance for mitigating such interactions. However, unlike fishing gear configuration changes, which have proven to be successful, reducing boat-strike interactions with sea turtles is a much more difficult objective to achieve, particularly in open coastal waters. The high frequency of turtles with healed injuries attests to the hardiness of loggerheads to thrive in an often hostile environment; however, it is also unclear how many sea turtles do not survive such encounters annually. As such, this study demonstrates the need for continued assessment of impact of boat-strike interactions with loggerheads in coastal foraging grounds.

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## USE OF SHARK DECOYS IN REDUCING INCIDENTAL CAPTURE OF SEA TURTLES IN THE LONG-LINE FISHERY

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An estimated 250,000 loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles are incidentally caught globally each year in the pelagic long-line fishing industry. Pacific populations of these species have plummeted 80-95% in the last two decades. Various gear and bait modifications as well as time/area closures to fishing enacted to reduce anthropogenic impacts on turtles have been ineffective or incompatible with regional fishing industries. Chemosensory and auditory deterrents have yielded little success to date in repelling turtles from the vicinity of long-line fishing operations. The fact that turtles are highly visual animals has precipitated a few field and lab studies to investigate the efficacy of using shark shapes in deterring them from long-lines. These studies have yielded promising results, but have lacked sufficient replication and scope to yield statistical rigor. To address this need, the present study has examined the response of 42 captive-reared loggerhead sea turtles to a shark model at the NOAA Sea Turtle Facility in Galveston, TX. To measure repulsive effect, time taken to consume squid bait beneath the shark was compared to that of squid beneath a control object (sphere) and also plain squid within a fifteen minute trial period. Additional data compared between these three treatments were time spent near treatment, number of breaths taken, approaches to the treatment, and avoidance behaviors displayed (e.g., turning carapace toward treatment). Prior to trials, turtles were fasted for three days. Turtles were given a fifteen minute acclimation to the experimental tank upon which a gate was raised and the fifteen minute trial period began. Attempts were made to make the shark visually realistic. The three-foot-long model was molded from a real black-tip reef shark (*Carcharhinus melanopterus*), and exhibited the black-tipped appendages of this species. The model also contained the counter-shading of a great white (*Carcharodon carcharias*), the blue metallic coloration of a shortfin mako shark (*Isurus oxyrinchus*), and was embedded with actual shark teeth and a realistic glass eye. The sphere was painted dark blue in contrast to the light blue background of the tank, and was approximately equivalent in surface area to the shark. Data analysis is currently underway.

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## ARTISANAL FISHING GEARS AFFECTING SEA TURTLES ALONG THE SOUTHWESTERN COAST OF THE GULF OF VENEZUELA: AN UPDATE

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Sea turtles are species globally threatened. Several natural and anthropogenic causes have been described affecting these species during their life cycle. Fishing activities, both artisanal and industrial, are mainly threats to sea turtles in feeding grounds. Detailed information exists about the industrial fishing gears impacts due to the efforts in regularizing their effects on marine life. However, the artisanal fishing gears lack governmental control and great questions still exist about their impact on the sea turtle populations. The Gulf of Venezuela (GV) is considered as one of the most important feeding areas to sea five species turtles in the Venezuelan coast and maybe in the Caribbean also. Green, Hawksbill, Loggerhead, Olive Ridley and Leatherback have been reported in the GV. This coastal zone is also the home of the indigenous community, the Wayúu, or Guajiros, whose now-illegal use to trade and consumption of sea turtles is deeply rooted in their magical-religious belief system. Wayúu people use at least three artisanal fishing gears that catch sea turtles. This research focused in to update the description and capture rate of sea turtles by the artisanal

fishery along the Southwestern coast of the Gulf of Venezuela. We visited four mainly southwestern fishing ports. We collected data from semi-structured interviews of fishermen and boat surveys during the fishing work from September 2006 to September 2007. Three artisanal fishing types were monitored to update their description: a) artisanal bottom longline, developed to 10-15 m depth, with five polypropylene lines, each with 900 m long. The hook number varied according to line length, but generally were 300 J4 hooks per line. The distance between hook along line varied between both, then the total of hooks was 1400-1800 per fishing vessel. The size of the fishing vessels used was 8 m long and 1.5 m wide, with a crew of 3 fishermen. Their main species target was the white catfish. b) artisanal bottom trawling, developed to 10-15 m depth with polypropylene monofilament gillnets which is dragged by two boats at the same time until the coast. These gillnets have 240 m long and mesh size measured 4". Species target were corvine and robalo. c) artisanal purse-seining gillnet, this fishing gear is more technical and selective. Require experienced fisherman who should be swim searching the fishes from the sound emitted by their natatorium bladder. This is a team work fishing method with four fishermen per vessel. When a fisherman found the fishes the boat leader closes the nets around the fish's bank. The nets were of dark polypropylene with 120 m long and 4-7" mesh opening. Species target were bigger fishes as such as corvine, robalo, mackerel. The mean number of sea turtles captured by these fishing gears was estimated in 3-10 turtles/year/vessel, mainly loggerhead turtles.

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## **SEA TURTLE BYCATCH IN THE MEDITERRANEAN: CAPTURES, MORTALITY, PRIORITIES\***

**Paolo Casale**

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The high fishing effort in the Mediterranean represents a major threat to sea turtle populations of the basin, due to both mortality induced by the fishing gear alone and the intentional killing of captured turtles. A full understanding of this threat is difficult to achieve, however a large amount of data have been collected. Although with a high degree of uncertainty, a review and analysis of this information and fleet statistics suggests that over 150,000 captures per year may take place in the Mediterranean by trawlers, longliners and set netters, with possibly over 50,000 deaths per year by interaction alone. Other deaths are caused by intentional killing, which is probably more important than commonly thought. Although the lack of adequate information on population dynamics does not allow understanding of how such a harvest may affect population growth, under a precautionary approach it should be assumed to be not sustainable. The analysis highlights the importance of artisanal fishery, since small fishing vessels are spread in very high numbers all over the basin. Unfortunately, measures and approaches to tackle the impact caused by the many small/artisanal vessels of the Mediterranean have not been investigated yet. Intentional killing remains a phenomenon difficult to remove, and it is mainly associated with artisanal fishing. An effective strategy considering both technical measures for large vessels and other measures for small ones should be urgently developed and implemented, probably at regional level and tackling the issue of ecosystem-based management of fishery as a whole.

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## **THE USE OF TURTLE EXCLUDER DEVICES IN SOUTHEAST ASIA\***

**Bundit Chokesanguan**

Training Department, Southeast Asian Fisheries Development Center (SEAFDEC/TD)

Since 1996 SEAFDEC Training Department has conducted numerous trials and demonstrations on the release of sea turtles from trawl fishing through the use of TEDs in the Southeast Asian waters including national waters off Thailand, Malaysia, Indonesia, Brunei and the Philippines. The results were then disseminated to fishermen, since shrimp trawling supports a large number of fishermen in the region. In order to continue the successful promotion on the use of TEDs in the region, the evaluation and assessment on the use of TEDs were conducted through questionnaires addressed to fishermen who were also interviewed in the countries that TEDs have been introduced. The assessment and evaluation aimed to find out the attitude of the fishermen and the people who were involved in the process of the applications and implementation regarding the use of TEDs. SEAFDEC, in cooperation with Southeast Asian Countries, will continue to promote the use of TEDs in Southeast Asia and other regions under the Project on

Responsible Fisheries, Technologies and Practices with the support of the Japanese Trust Fund as well as funds provided by GEF/UNEP/FAO to support the activities which are part of the Reduction of Environmental Impact from Tropical Shrimp Trawling Project Phase I and II.

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## **PROMOTION OF THE USE OF CIRCLE HOOKS IN SOUTHEAST ASIA**

**Bundit Chokesanguan and Somboon Siriraksophon**

Training Department, Southeast Asian Fisheries Development Center (SEAFDEC/TD)

SEAFDEC Training Department, as a technical agency in the promotion of responsible fishing technologies and practices in the Southeast Asian region, has studied the mitigation of fisheries-sea turtle interactions through experiments on the efficiency of circle hooks in comparison with J hooks in longline fishery in Southeast Asian waters. The study objectives are to investigate the efficiency of circle hooks as compared to J hooks, the hooking positions between two different types of hook and the impact of longline fishery on mortality of sea turtles caught incidentally in waters of the Southeast Asian region. Six experiments have been conducted in the Andaman Sea, waters of Brunei Darussalam, waters of Myanmar, waters of Thailand, the Celebes Sea of the Philippines and the Indian Ocean. The results of the experiments revealed that the efficiency of catch was not different between these hooks but that shark and other non valued by-catch was reduced by 20% by using circle hooks instead of J hooks. As for the position of hooking of circle hooks, 85% of fish were caught at the mouths and 4% in the digestive system. On the other hand, 25% of fish were caught in the digestive system in the case of using J hooks. In order to reduce catch of sea turtles in longline, the promotion on the use of circle hooks was conducted through training/workshops in the Philippines, Indonesia, Thailand, Vietnam and Malaysia in 2006-2007. The information packages were also produced and disseminated in the region for that purpose. SEAFDEC in cooperation with Southeast Asian countries will continue to promote it in the region under the Project on Responsible Fisheries Technologies and Practice with the support of the Japanese Trust Fund and other organizations in other regions.

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## **PELAGIC STAGE LOGGERHEAD SEX RATIO: EVIDENCE OF DIFFERENTIAL MORTALITY BETWEEN MALE AND FEMALE JUVENILES**

**Cláudia Delgado, Telma Ferreira, and Thomas Dellinger**

Laboratório de Biologia Marinha e Oceanografia, Universidade da Madeira, Portugal & Centro de Estudos da Macaronésia

Like many other reptiles, loggerhead turtles exhibit temperature-dependent sex determination (TSD), i.e., the sex of the offspring is influenced by the incubation temperature of the eggs. Temperature-dependent sex determination has the potential of producing biased sex ratios. Therefore, the sex ratios produced from TSD are of ecological interest, as knowledge on the population's sex-ratios is essential for wild populations' management and conservation. In this study, we assessed the sex ratios from two sets of samples from the juvenile loggerhead population in the waters around Madeira Island, Portugal, NE Atlantic, between the years 1999-2007. Since marine turtles do not present any sexual dimorphism during the juvenile pelagic life stages, individual sex needs to be diagnosed through direct techniques, i.e. macroscopic observation of the gonad. Live turtles were caught offshore and brought in to laboratory and laparoscopies were performed in order to determine each animal's sex. Dead turtles originated from bycatch from the black scabbard fisheries were collected and necropsies were performed in order to directly observe the gonad and determine each animal's sex. Sex ratios obtained for the live population were compared to the one obtained for the by-catch one. Although females predominated in both sub-sets, live turtles showed a 2F:1M sex-ratio, while the sex ratio derived from by-catch fisheries was 4F:1M. Hence, pelagic sex-ratios derived from live turtles vs. accidentally killed (by-catch) are different. This work demonstrates that, although important, sex ratios derived from by-catch fisheries are not accurate for population modelling as they seem to be strongly biased from the operational or functional sex-ratios, i.e., they do not reflect the sex ratios recruiting at maturity. Potential explanations for these differential sex-ratios at the pelagic life stage of loggerhead marine turtles are discussed. The authors acknowledge the International Sea Turtle Symposium and the following organizations: Australian Government DEWHA, Queensland Environmental Protection

Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, US National Marine Fisheries Service, US Fish and Wildlife Service (Marine Turtle Conservation Fund) and the Marisla Foundation for providing a traveling grant to attend the Symposium.

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## **THE TURTLE CSI - INTERPRETING MARINE TURTLE STRANDING DATA, WITH MARINE (FORENSIC) TAPHONOMY EXPERIMENTS\***

**Thomas Dellinger<sup>1</sup>, Janine Karla França da Silva<sup>2</sup>, and António Jorge Martins<sup>3</sup>**

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Turtles stranded along the coastlines are a convenient indicator of at-sea mortality. However, the step from quantitative stranding data to mortality is largely based on circumstantial, correlative or intuitive data or reasoning, and rarely based on sound experimental evidence. Stranding frequency has been usually related to at-sea mortality only in situations where anthropogenic causes produce large mortalities. The usual method to access mortality rate is repeated beach censusing combined with removal or marking of already counted carcasses. These are of course minimal estimates since not all turtles that die will get stranded. For pelagic stage sea turtles that die, probably the majority of them, will sink before wind and currents can transport them ashore. To use stranding data to infer turtle mortality at least two types of information must be obtained: (1) taphonomic data that describe the duration of carcass floatability and decomposition and (2) oceanographic data pertaining to surface currents to access distance and direction of carcass movement. Here we present data related to the 1st condition, and describe the decomposition process of fresh turtle carcasses obtained from longline bycatch. Carcasses were left to decompose simultaneously both inwater (n=3) and onshore (n=3). The decomposition process generally followed the stages described for mammals (fresh, bloat, advanced, and remains) but differed markedly between the terrestrial and marine environments. While stranded carcasses mummified, inwater carcasses saponified, sank and were rapidly consumed by necrophagous species. Carcass floatability varied between 13 and 31 days and body size may influence this duration positively. Following these results a more detailed decomposition stage system is proposed that integrates both marine and terrestrial decomposition to allow for better estimation of time since death intervals for stranded carcasses. Finally our experimental results are applied to existing stranding data for Portugal to roughly estimate areas of origin for turtle mortality.

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## **GENERATING MORE SUPPORT TO REDUCE SEA TURTLE BYCATCH ON THE HIGH SEAS**

**Marydele Donnelly**

Caribbean Conservation Corporation

During the last decade, the United Nations, Food and Agriculture Organization (FAO), regional fishing management organizations (RFMOs), international instruments, and individual nations have worked to identify and reduce the detrimental effects of high seas fisheries on sea turtles. In 2005 the United Nations General Assembly adopted a resolution calling on countries to close fishing areas where large numbers of sea turtles and other protected species are captured, and FAO's Committee on Fisheries adopted "Guidelines to Reduce Sea Turtle Mortality in Fishing Operations." In recent years, five RFMOs have addressed the need to reduce sea turtle bycatch (the unintentional capture of non-target species) in various ways; two of these RFMOs were encouraged to act by a 2006 resolution passed by the International Sea Turtle Symposium (ISTS) asking them to address this issue. Despite some progress, tens of thousands of sea turtles are captured, injured and killed in high seas fisheries each year as the world's fishing fleets increase capacity and effort. The lack of international commitment to reducing bycatch and the current RFMO focus on declining stocks of tuna from overfishing, such as dramatic declines of big-eye tuna in the Eastern Pacific Ocean, has resulted in the RFMOs failing to provide sufficient attention to bycatch reduction or back-sliding on agreements. This current state of affairs gives greater impetus for action within the international instruments for sea

turtles, such as the Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia (IOSEA) and Inter American Convention for the Protection and Conservation of Sea Turtles (IAC). Parties to the IAC are expected to adopt "Guidelines for Reducing Sea Turtle Mortality, drafted by its Scientific Committee, at the Fourth Conference of the IAC Parties in November 2008. This presentation will review the status of international efforts by the RFMOs, international agreements and the world's organizations to reduce the bycatch of sea turtles on the high seas and will recommend steps that need to be taken, such as expanding observer coverage, data collection and promotion of mechanisms to reduce bycatch within international instruments. The ability of the United States to promote bycatch reduction through technological advances and experiments and the potential to generate international cooperation through bilateral and multilateral discussions under new U.S. legislation that requires countries exporting fish and fish products to the United States to match U.S. bycatch reduction on the high seas also will be reviewed.

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## **HIGH JUVENILE SURVIVAL RATES OF TURTLES: IMPLICATIONS FOR CONSERVATION AND MANAGEMENT\***

**Tomo Eguchi**

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Due to the difficulty in capturing juvenile reptiles, it has been speculated that reptiles have high mortality during the juvenile stage. A recent study has indicated, however, the high mortality of juvenile reptiles is a myth. Because of their longevity, without high survival rates during juvenile stages, a population cannot sustain itself. In this study, I show another line of evidence for high survival rates of juvenile turtles through simple mathematical relationships among life history parameters. For a variety of turtle species, stage-based projection matrices (Lefkovich matrices) were created using published life history parameters (age at first reproduction, fertility, and adult survival rates). Juvenile survival rates in the matrices were treated as unknown parameters. Assuming that a natural population of a reasonable size without additional consistent mortality (e.g., harvest) would sustain or increase its population size, the dominant eigen value (i.e., the asymptotic population growth rate) was set to one. The characteristic equations, then, were solved for the juvenile survival rates. For the stage-based matrices, these solutions were the lower bound of the average survival rate for the entire juvenile stage. For a variety of species, computed average juvenile survival rates were high, though the actual estimates were affected by the age at first reproduction, fecundity, and survival rates of other stages. Assuming that survival rates increase with age, the maximum possible population growth rates without immigrations also were investigated. For slow maturing species, such as the snapper (*Chelydra serpentina*), Blanding's (*Emydoidea blandingii*), loggerhead (*Caretta caretta*), and green turtles (*Chelonia mydas*), the approximate maximum rate was 15% per annum. High natural survival rates of juveniles and adults, combined with low potential population growth rates, indicated that a turtle population may not sustain continuous harvest and anthropogenic mortalities. Through a simulation study, I show that improvements on hatchling survival alone may not compensate for additional mortalities in juveniles and adults. In order to successfully conserve turtle species, therefore, it is essential to improve adult and large juvenile survival rates, in addition to the nesting beach protections. These findings are consistent with previous studies on long-lived species and add support for conservation of adult and juvenile turtles. Finally, results of population analyses, such as viability analyses, are sensitive to a few vital rates, especially the age at first reproduction. Therefore, it is imperative to conduct studies that can provide precise estimates of the age at first reproduction of turtle species. Without such studies, successful management and conservation of turtle species are doubtful.

## **SEA TURTLE BYCATCH REDUCTION IN THE U.S. ATLANTIC PELAGIC LONGLINE FISHERY\***

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In 2004 the National Marine Fisheries Service promulgated regulations requiring the use of 16/0 or larger circle hooks in the Atlantic pelagic longline fishery and implemented careful release protocols to remove gear from the captured turtles. The agency believed the regulations would reduce the bycatch of leatherback turtles and the mortality of both leatherback and loggerhead turtles by about 50%, comparable to what had been achieved in their 2002-2003 experiments in the central North Atlantic (Watson *et al.* 2005, BiOp 2004). We compare observer data for the 3 years prior to and after the regulations were enacted in order to evaluate the effectiveness of the regulations. We also evaluate the results in light of the size distribution of the turtles captured, hook sizes and bait used, and feeding experiments on captive reared loggerheads 45-65 cm, exposed to different sizes of hooks, types of bait, and baiting styles.

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## **CUMULATIVE SEA TURTLE BYCATCH ESTIMATES ACROSS US FISHERIES AND THEIR RELATIVE IMPACTS ON NESTING AND REPRODUCTIVE STOCKS**

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Cumulative impacts of sea turtle fisheries interactions are difficult to assess due to low levels of observer coverage, discrepancies in data collection methods, and large temporal and spatial gaps in data. Furthermore, logbook derived estimates of turtle takes may only account for a small percentage of total takes. Despite these obstacles, cumulative impacts across fisheries need to be assessed as most take limits are currently set for individual fisheries with little regard for how the sum of those interactions impacts sea turtle populations. We reviewed all literature pertaining to fleet-wide extrapolations of sea turtle take and mortality events in US fisheries between 1990 - 2007. In the absence of fleet-wide estimates, raw data from observer programs were used in conjunction with fisheries' characteristics to extrapolate estimates of turtle take and mortality. Estimates are divided into pre and post regulatory strata, and reported as fishery-specific annual means and confidence intervals. Mean and confidence interval estimates are then added across fisheries within pre and post regulatory strata. Furthermore, cumulative bycatch estimates are placed within a population context to assess relative impacts of bycatch on nesting and reproductive stocks. As it is increasingly evident that fisheries interactions pose a major threat for sea turtles residing in US waters, such information is germane for assessing population impacts of fisheries interactions.

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## ASSESSING SEA TURTLE BYCATCH AND MORTALITY IN NORTH PERU: A COMMUNITY CONSERVATION INITIATIVE

**Kerstin S. Forsberg**

Proyecto Tortugas Marinas - Tumbes

Sea turtles in Tumbes, the northernmost Peruvian region, are scarcely protected. They are frequently caught as bycatch and found dead in numerous quantities along beaches. Lack of conservation initiatives for these species in the region is greatly due to insufficient research on sea turtle biology and human activity impacts; as well as a lack of environmental awareness and community commitment to conservation. In order to introduce sea turtle conservation initiatives in the area, PROYECTO TORTUGAS MARINAS- TUMBES, PERU motivated several members of the community to collaborate and volunteer in assessing fishing activity interaction with sea turtles, by evaluating sea turtle bycatch and mortality in the area. Thus, over 50 local volunteers were trained in technical workshops and later divided in two groups: one, involved in a continuous sea turtle on-board observation program (aboard artisanal purse-seines and trawlers) and the other in monthly coastal patrols; both activities during the whole year 2008. Volunteers were monthly assessed and given complementary training to assure data efficiency. Community commitment with the project was further reinforced by monthly meetings with local governmental, scientific and educational institutions. On-board observers collected data of both fishing gear and morphometrics of bycatch turtles on fishing trips near Zorritos (03°40'S, 80°40'W) and Caleta Cruz (03°38'S, 80°35'W). Coastal patrols took place from Cancas (03°56'S, 80°56'W) to Playa Hermosa (03°33'S, 80°31'W), where morphometric data of carapaces and stranded turtles was collected. Seasonality in sea turtle beach mortality was compared to seasonality in fishing effort (of purse seines and trawlers, and also long lines and gillnets) in order to approximate potential relationships between both. From January to August 2008, 177 sea turtles were found dead along beaches, with 56.5% of this mortality represented by sea turtle carapaces (individuals hunted for meat and derived use); and 29,94% defined as beachings. Mortality was mainly represented by *Chelonia mydas agassizii* (67.23%), followed by *Lepidochelys olivacea* (15.25%) and *Dermochelys coriacea* (1.13%). CCL for *C. mydas agassizii* ranged from 48.5 cm to 91.5 cm ( $61.79 \pm 7.66$ , n=88) and for *L. olivacea* from 52.0 cm to 69.5 cm ( $63.40 \pm 4.47$ , n=23), meaning that most *C. mydas agassizii* found were probably juveniles, whilst *L. olivacea* probably consisted of juveniles and sub-adults. This is why we think it is more likely for *L. olivacea* to sporadically nest in north Peru. Few individuals of both species were also found to be probable adults. Bycatch mainly consisted of *Chelonia mydas agassizii*, although a juvenile *Eretmochelys imbricata* was also reported caught in a purse-seine for the first time in Peru. Most turtles were retrieved from the fishing gear in good conditions and were released alive after capture. Bycatch was greatest in June to August, yet we highlight that this data is to be further complemented by data collected through September to December 2008. This information will contribute to further understanding and conservation initiatives for sea turtles in north Peru and the East Pacific. It will also provide motivation for local people and organizations to continue engaging in community conservation efforts. Acknowledgements: Funding for this project was provided by the Scott Neotropical Fund (Cleveland Zoological Society/Cleveland Metroparks Zoo), the Explorers Club and the Universidad Nacional de Tumbes. Fieldwork was made possible thanks to volunteers from Dirección de Producción del Gobierno Regional de Tumbes, Universidad Nacional de Tumbes, Instituto Superior Tecnológico Contralmirante Manuel Villar Olivera and Instituto Superior Tecnológico José Abelardo Quiñones. Flipper tags were provided by NOAA. Fishing effort data was provided by Dirección de Producción del Gobierno Regional de Tumbes and Instituto del Mar del Peru. This poster presentation was made possible through a travel grant provided by the International Sea Turtle Symposium, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund). Special thanks to Carmen & Lars Forsberg, Vector Peru S.A.C and Fernando Casabonne for all their support during the development of this project.

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## **WE NEED A U.S. LAW REQUIRING TURTLE EXCLUDER DEVICES, AGAIN**

**Elizabeth Griffin, Michael Hirshfield, David Allison, and Beth Lowell**

Oceana, Washington, D.C.

Most people think the problem of sea turtle bycatch in trawls was solved through the use of Turtle Excluder Devices (TEDs) in shrimp trawls. However, the majority of trawl fisheries, although they fish in similar ways and in similar areas to shrimp fisheries, are not required to use TEDs. In the U.S. that may soon be changing. Bycatch in trawl fisheries is one of the largest known anthropogenic causes of sea turtle mortality. The number, age and species of sea turtles captured in trawl fisheries fluctuate based on the season and geographic location of fishing activity. Trawl fishing often occurs in coastal areas that are prime sea turtle habitat, where trawls capture larger, older and more reproductively “valuable” turtles more frequently than many other fisheries, and therefore can have a major impact on sea turtle populations. TEDs are widely accepted as a valuable bycatch reduction tool in shrimp trawls and can result in a 97% reduction in turtle net entrapment. In 1992, the first U.S. TED regulations were established for shrimp trawls and bottom trawls fishing in certain areas for summer flounder. The U.S. Congress extended the TEDs requirement internationally by requiring countries wishing to export shrimp to the U.S. demonstrate a level of sea turtle protection equal to that of the U.S. While the U.S. has taken protection of sea turtles from shrimp fisheries seriously, it has failed to prevent sea turtle casualties by other trawl fisheries. The majority of U.S. trawl fisheries operating in areas inhabited by sea turtles are not required to use TEDs. Trawl fisheries in the U.S. Mid-Atlantic region demonstrate the severity of this problem. An estimated 770 sea turtles are caught annually in Mid-Atlantic bottom trawl fisheries. Of these fisheries, only the summer flounder fishery is currently required to use TEDs. In 2007, the U.S. National Marine Fisheries Service (NMFS) announced it was considering developing regulations to require TEDs in additional trawl fisheries. This development raises important international considerations. First, it sheds light on the fact that shrimp trawls are not the only trawls with sea turtle bycatch problems. Globally, trawl fisheries operating in areas with sea turtles should be examined to determine if bycatch mitigation measure, such as TEDs, are needed. If bycatch problems exist, research should begin to develop appropriate TEDs. Additionally, the U.S. recently updated its law that governs fisheries management, the Magnuson-Stevens Fishery Conservation and Management Act (MSA) to include a process to address bycatch of protected marine species when they leave U.S. waters. Should the U.S. move forward as planned with new TED regulations, the U.S. would be in a position to strongly encourage other countries to do the same. It is time for international collaboration to reduce sea turtle bycatch in trawl fisheries and to reverse the threat of extinction that has long plagued sea turtle populations.

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## **IMPLEMENTING CHANGE; PROGRESS AND CHALLENGES IN BYCATCH MITIGATION IN EASTERN PACIFIC LONGLINERS\***

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Among the main factors causing mortality of sea turtles in the eastern Pacific region are hookings and entanglements in longline gear. A program was started in late 2003 in Ecuador, to test a set of potential solutions to mitigate these impacts. It has expanded to the whole Pacific coast of America, from Chile to Mexico. This program is the result of the cooperation between the national fisheries agencies, the fishing sectors in each country, local and international conservation organizations, with technical support from the National Oceanographic and Atmospheric Administration (USA), the Inter-American Tropical Tuna Commission (IATTC), and the Overseas Fishery Cooperation Organization of Japan (OFCF). These include changes of J hooks for circular hooks, adoption of larger hooks, adoption of instruments and procedures to release sea turtles, training of fishers in their use, and communication with all interested parties to proceed to implement the changes. The program is at different stages in different countries (e.g. just beginning in Nicaragua and Chile, and quite advanced in Ecuador), but it is time to start plotting the next steps based on the results observed. One of the activities that advanced considerably during the past year was the description and quantification of the artisanal fishing fleets of the region, including longliners and gillnetters, an element needed to extend the transformation process, assess costs, and define priorities. Another area of progress is the scientific approach to increasing the survival of sea turtles through improved handling of the hooked and entangled individuals coming from the incorporation of veterinarians to the team. Several projects are underway on this subject. Also, a recent report from a workshop on statistical aspects of data analysis contributes fresh ideas for some tests of the effectiveness of the mitigation measures. The report can be found at <http://www.iattc.org/PDFFiles2/SpecialReport17.pdf> Other statistical approaches are continuing to be explored. This presentation will review the results up to date, and the recommendation for follow up actions. These recommended actions will include replacing J hooks, defining the minimum set of instruments to be carried by fishing boats, establishing clear and simple procedures to be followed to remove hooks, to disentangle, and to release the turtles.

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## **THREATS TO SEA TURTLES IN BANGLADESH COASTAL AND MARINE WATERS**

**Mohammad Z. Islam**

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Bangladesh is situated at the north of Bay of Bengal and comprises 710 kms of coastline, of which several hundred are sandy and suitable for sea turtle nesting. It is estimated that five species frequent our marine territory; those species also occur in other south Asian countries while olive ridley, green turtle and hawksbill have authentic records of nesting in Bangladesh. Sea Turtles in the Bangladesh marine territory face many threats related to fishing activity and pollution. Sea turtle conservation is an initiative that started 11 years ago (1996) at St. Martin Island. This presentation depicts the overall threats status for sea turtles in coastal and marine areas of Bangladesh. Offshore fisheries, coastal development, tourism and pollution cause sea turtle mortality and loss of nesting habitat. More than a thousand adult & sub adult individuals strand along the coast of Cox's Bazar each year. Nesting beaches are being fragmented and shortened gradually at an alarming rate. As for the causes of mortality of turtles at sea, the existing knowledge is only linked to gillnet fisheries and the shrimp trawl fisheries. One of the major threats related to the fishing activities is the use of Marine Set Bag Nets (MSBN). This is now one of the major fishing methods in coastal and shallow marine waters and involves of a huge number of fishermen and boats. There is no current census at hand to judge the situation regarding the MSBN fisheries but at least several thousands of nets remain deployed during the fishing season most of the time in a year except during the rainy season. Usually 4-10 nets are in a set managed by one boat and remain in offshore areas at a depth of 10-20 meters. Unlike the shrimp trawl nets, these remain in an area and fish are intaken by tidal water in both water incoming and water outgoing time. To reveal the magnitude and understand the intensity of the by-catch we are conducting a survey with the help of fishermen and found an alarming rate of captures. 32 boats have been included in the survey for a period of 2-6 weeks during the 2005-08 fishing seasons. During the survey, a total of 312 MSBN were used and 382 sea turtle captures were recorded in this gear. Fishing activity with MSBN is not widely used and is possibly absent in other countries while it is not well known by the international community. It is necessary to explore the migratory routes, bycatch rate, TED initiative and extend nesting turtle monitoring and conservation at all suitable nesting beaches. Concurrently with the in-country legislation and initiatives for conservation efforts it is important to impose an international ban on shrimp trade to stop mortality by trawl fisheries since in Bangladesh TEDs are not used in mechanized trawlers.

## **MARINE TURTLE BYCATCH IN THE INDUSTRIAL PRAWN TRAWL FISHERY IN THE UNITED REPUBLIC OF TANZANIA**

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A survey of the Tanzanian industrial prawn trawl fishery was conducted between June and September 2007 to determine the level of incidental capture of marine turtles and mammals. Trained observers from the Tanzania Fisheries Research Institute and Prawn Trawl Association boarded 5 out of 10 vessels operating along the coast. 16 turtles were caught in 5 of the vessels, comprised of three species: green (62.5% of total), hawksbill (19% of total) and loggerhead (12.5% of total). Most (81%) were caught in the northern and central part of the coast (Zones 1 and 2) during August. Based on a fleet of 10 vessels (the number licensed in 2007) it is estimated that 54 turtles are caught annually providing justification for the experimentation of TEDs and their mandatory use in Tanzanian legislation. In January 2008, the Tanzania Prawn Trawl Association decided to close the industrial prawn trawl fishery for two years between 2008 and 2010 due to declining prawn yields, destruction of the benthic environment and to allow research on maximum sustainable yields to be carried out. Upon reopening, it proposed that no new licenses be issued. Recommendations from this survey include: experimentation with TEDs; introduction of legislation on mandatory use of TEDs in the industrial prawn fishery; conducting a longer term survey to determine turtle catch levels; and developing a bycatch database.

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## **CAN SEA TURTLE STRANDINGS BE EXPLAINED THROUGH FISHING EFFORT? A CASE STUDY FROM BCS, MEXICO**

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While sea turtle stranding networks have existed for many years now, very little information is available on mechanisms governing these events. From March 2006 to June 2008, we surveyed sea turtle mortality on 220 km of coastline all around the state of BCS (10% of total coastline). In total we found 757 dead sea turtles, but the mortality cause was established only in 15% of the carcasses, with fisheries being by far the most important one. This led us to the first question: Which are the variables that influence sea turtle strandings? And then, how much of the strandings can be explained by fishing effort in the nearby fishing area? In an effort to answer these two questions, we combined both GIS and GAM methodology. First of all we selected oceanographic, biological and anthropogenic variables that could explain the presence/absence of strandings on a beach: sea surface temperature, chlorophyll concentration, wind strength and direction, approximate distance of feeding areas from the coast, seasonal variations of sea turtle abundance (presence/absence), location of fishing areas and fishing effort. The multivariate function was used to determine the relationship between variables. We then used the GAM function to estimate the impact of fishing effort on strandings. Here we present preliminary results of this study.

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## **A REVIEW OF STRANDING RECORDS OF LEATHERBACK SEA TURTLE (*DERMOCHELYS CORIACEA*) ALONG GULF OF VENEZUELA: ARTISANAL GILLNET FISHING MAYBE IS AN IMPORTANT THREAT**

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The Gulf of Venezuela (GV) has been considered to be one of the most important feeding areas in the Venezuelan coast and maybe in the Caribbean as well. Five sea turtle species have been reported: green, hawksbill, loggerhead, olive ridley and leatherback. In particular, leatherback sea turtles, at least for the last ten years, have been recorded only from dead stranding data. Stranding data collected by Grupo de Trabajo en Tortugas Marinas del Golfo de Venezuela (GTTM-GV), since August 2001 were analyzed to identify: 1) a stranding greatest area, 2) a stranding greatest period, and 3) potential causes. Surveys on ~160 km of coast line were carried out, at least every 1-3 months from August 2001 to June 2004, and once every month from July 2005 to September 2007. We collected information about the place, date and specimen condition of stranded leatherback sea turtles, and when it was possible we registered morphometric data. Death causes were determined when possible, categorizing the carcasses as follows: a) interaction with fishing gear in cases where carcasses were entangled in gillnet fishing or bore marks of other fishing gear; b) unknown mortality, in cases where no obvious cause of mortality was observable. Between 2000 and 2007, 57 leatherback sea turtle dead strandings were recorded throughout GV coast. Mean CCL was 126 cm (86-168 cm, n=48) and mean CCW was 99cm (83-109cm, n=48). Size data indicates that GV's coastal waters are frequented both by juvenile and mature leatherback sea turtles, maybe beginner females. No marks of previous tags were observed in any of specimens found still in good condition. Two stranding greatest areas were identified along the GV: the north coast (49% n=28) and the south coast (46% n=26). Sporadic stranding events were reported on the central coast (5% n=3). The majority of the stranding events were concentrated between February – March (51%, n=29), August-September (42%, n=24), and 7% (n=4) scattered in the remaining months. Analyses of the data reflect a seasonal pattern of strandings, and this pattern is coincident with the periods of pre and post leatherback turtle nesting season in the Venezuelan east coast. A 45% (n=25) of stranding events was recorded unknown mortality. The other 55% (n=32) showed signs of interaction with fishing gear, of which 59% (n=19) corresponded to artisanal gillnet fishing. At least, another two artisanal fishing gears affecting sea turtles have been described within the GV, then it is difficult to specify which is the responsible of these strandings without more research focused on this. However, we report two first confirmed deaths of leatherback turtles by entanglement in artisanal gillnet fishing in September 2007. The artisanal gillnet fishery has been reported by other authors as an important cause of death to female nesting leatherback turtles from Caribbean rookeries. However, the effects of this on populations and other sea turtle species are poorly understood. Our results suggest that research should focus on the assessment of the % mortality by artisanal gillnets, and to confirm the interaction of leatherback sea turtle stranded with another artisanal fishing gear.

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## **INCIDENTAL CATCH OF THE LOGGERHEAD TURTLE, *CARETTA CARETTA*, IN THE NORTHERN TYRRHENIAN SEA (NW MEDITERRANEAN)**

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Since 1993, the Municipal Aquarium of Grosseto (Tuscany, Italy) has been engaged in the activity of rescue, recovery and release of sea turtles in the northern Tyrrhenian Sea (NW Mediterranean). During the period of activity, the volunteers of the Municipal Aquarium of Grosseto have recovered a total of 141 specimens of loggerhead sea turtles, *Caretta caretta*: 40 specimens were found dead, 7 died during the stay in the Aquarium, 88 were released and 6 are still hosted by the Aquarium. The majority of the loggerheads were sub-adults. The northern Tyrrhenian Sea is an isolated basin: its connections with the rest of the NW Mediterranean occur at depths of about 500 m. In addition, it is characterized by the stability of the water column, high temperatures and high productivity. This area is mainly exploited by the bottom trawlers of the fleet of Porto S. Stefano, Porto Ercole and Castiglione della Pescaia. The small scale fishery is represented by a low number of small vessels working close to the coastline with trammel nets, gill nets and traps; only few vessels are targeting swordfish and tuna using pelagic long-lines. Due to the prevalence of the trawl fishery in the northern Tyrrhenian Sea, the major part of the specimens of loggerhead sea turtle recovered by the Aquarium were provided by trawl vessels: a total of 99 specimens were caught by trawling. The time series of turtle catches showed an oscillating behaviour, with two main peaks in 2003 (27 specimens recovered) and in 2008 (28 specimens from January to May). Therefore, it was attempted to relate the accidental catches of loggerhead sea turtle to the time series of mean monthly data of some explanatory variables, such as the sea surface temperature, the wind speed, the North Atlantic Oscillation (NAO) index, and the total number of days at sea of the trawl vessels of Porto S. Stefano. The analyses were carried out by means of the cross-correlation function performed by the software package Brodgar 2.5.1 ([www.brodgar.com](http://www.brodgar.com)). The time series of *C. caretta* catches resulted significantly related to the sea surface temperature ( $r = -0.36$ ,  $p < 0.05$ ) and to the wind speed ( $r = 0.28$ ,  $p < 0.05$ ). These results suggest that during the coldest months, when the trawl vessels work closer to the coast due to the bad weather conditions, the catches of loggerhead sea turtle are higher. In summer and autumn, when the trawlers exploit the Norway lobster (*Nephrops norvegicus*) fishing grounds, the accidental catches of *C. caretta* are lower. As a matter of fact, more than the 65% of the specimens were caught from January to April. The peak of catch was in March: a total of 45 specimens was caught. However, the dormant winter submergences (overwintering) performed close to the sea bottom could increase the vulnerability of sea turtles to the trawl nets during the cold months as well. The authors would like to thank the Symposium organization, as well as the Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation for providing a travel grant which ensures our participation to the Symposium.

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## **ACCOUNTING FOR THE INCIDENTAL CATCH OF SEA TURTLES AND OTHER PROTECTED SPECIES IN PRODUCTIVITY MEASUREMENTS: APPLICATION TO THE CA/OR DRIFT GILLNET FISHERY**

**Tara L. Scott**

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Undesirable harvest such as juvenile fish, marine mammals, sea birds, and sea turtles are captured along with target species such as swordfish and thresher sharks in drift gillnets off the coasts of California and Oregon. Beginning in August of 2001, regulatory measures to reduce the take of endangered species (e.g. leatherback sea turtles) resulted in

the annual closure of an area located between Point Conception and 45 degrees north latitude, for the time period August 15 to November 15. This regulatory closure acts as a natural experiment for assessing the impact of the time-area closure on the productivity of the California/Oregon Drift Gillnet Fishery. Typical measures of productivity ignore the joint production of undesirable and desirable outputs since data on undesirable outputs are seldom available. The productivity measure used in this paper models the joint production of undesirable and desirable outputs, crediting fishing trips with reductions in incidental capture of sea turtles and other undesirable species and increases in desirable. By incorporating sea turtle interactions into the production process, more accurate measures of economic productivity can be calculated. Fisheries managers can use the estimates to design and implement effective policies to maintain or improve a fishery's economic performance with the simultaneous goal of reduced sea turtle interaction. A directional output distance function approach is used to measure total factor productivity of the fishery pre- and post-closure for the time period 1996-2006 to elucidate the effects of the closure on the conservation of sea turtles and the economic performance of the fishery. Trip-level data from the National Marine Fisheries Service Drift Gillnet Fishery Logbooks and PacFIN database were used to estimate productivity. Valuation of sea turtles and other protected species is accomplished by the calculation of the species' shadow price. This measure is a lower bound estimate of the social costs of conservation. It can also be interpreted as the amount of swordfish that would be forgone to protect one more sea turtle. Fisheries managers can use this estimate to evaluate the trade-offs between fleet-wide economic productivity and sea turtle interactions.

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## **MID-WATER FLOAT SYSTEM WITH LONG FLOAT LINES TO AVOID SEA TURTLE BYCATCH\***

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Sea turtle bycatch issues are of special concern in tuna longline fisheries. To avoid sea turtle bycatch, we developed mid-water float (mid-F) system as a method of setting the hooks at almost the same depth. When enough long float line (FL) was deployed with mid-F system, all hooks could be set in water deeper than where sea turtles predominantly swim and in the depth of tuna habitat. Sea trials of full-scale longline gear with mid-F and long FL (100m) were carried out in the Indian Ocean. One mid-F was attached to the center of one-basket mainline, both ends of which were hung with the two long FLs. The conventional setting (the length of FLs were 40m) without any mid-F was also conducted as a control. All hooks of mid-F system with long FL were set below 150m at the appropriate shortening rate, sufficiently below sea turtles habitat. Moreover, the depth range of hooks with mid-F system was at most 50m, while that of the conventional setting was over 120m. The CPUE of bigeye tuna on the hooks below 150m was about 3 times higher than that above 150m, and estimated catch number of bigeye tuna in the longline with mid-F and long FL increased nearly 30% as compared with the conventional setting. This suggests that deep hook-setting with the mid-F and long FL system allows for more efficient catch of tuna as well as for avoiding sea turtle bycatch.

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## **DO HOOKS MODIFIED WITH WIRE APPENDAGES MINIMIZE DEEP HOOK INGESTION RATES IN INCIDENTALLY CAPTURED LOGGERHEAD (*CARETTA CARETTA*) SEA TURTLES?**

**Lesley Stokes<sup>1</sup>, Dominy Hataway<sup>2</sup>, Charles Bergmann<sup>2</sup>, Sheryan Epperly<sup>1</sup>, and Ben Higgins<sup>3</sup>**

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Protected species bycatch is a serious issue for hook-and-line fisheries, and innovative gear modifications may reduce the incidence and severity of these encounters. Increasing hook diameter may help to minimize sea turtle bycatch, but may not be practical in some fisheries due to target species loss. In studies investigating hooks modified with a wire appendage, gut hooking rates and undersized catch of snapper were lower than found using conventional hooks (Willis

and Millar 2001, Barnes *et al.* 2006). Given that mouth-hooking causes less injury to sea turtles than deep ingestion (Epperly and Boggs 2004), we investigated whether hooks modified with a wire appendage could minimize injury in incidentally captured sea turtles. We examined the effects of hook size (14/0, 15/0 and 16/0, turtle size (45, 55 and 65 cm SCL size classes), and baiting type (squid and sardines) and technique (“single” and “threaded”) on loggerhead sea turtles’ ability to swallow a baited appendaged hook. AP39960D Mustad circle hooks, with blunt wire appendages (31 - 39.5 mm long) braised at a 53° angle to the shank of the hook, were modified to prevent injury by removing the barb and wrapping the end. Baited hooks were offered (taken before injury could result) to captive reared loggerheads, and the turtle’s response was recorded. Results showed that as hook size increased, the percentage of turtles attempting to swallow the hook generally decreased; bait type and technique also were critical. Turtles were less likely to ingest hooks baited with sardines than squid, and less likely with “single” rather than “threaded” baits. Results are likely due to differences in bait texture, shielding effects, and behavioral differences in how turtles respond to different hook/bait combinations. Over 50% of the 45 cm turtles attempted to swallow 14/0 hooks with squid, but ingestion rates dropped as hook size increased and with sardines for all hook sizes. Results for 55 cm turtles were similar, with ingestion rates highest with 14/0 and 15/0 hooks and with squid bait. In contrast, the 65 cm turtles attempted to swallow 75-100% of hooks baited with squid, and 0-55% of hooks baited with sardines. In general, sea turtles attempted to swallow fewer 16/0 appendaged hooks compared with non-appendaged hooks, but the effect was minimal with 65 cm turtles. The 14/0 appendaged hooks did not reduce the deep ingestion rate for 55 cm or 65 cm turtles compared with non-appendaged 14/0 hooks. The appendage prevented ingestion by smaller turtles because it lodged in the corner or roof of the mouth. The larger turtles were able to bend the appendage easily, and they were not deterred from ingesting hooks and bait, particularly squid. Our study supports previous research illustrating that bait type, and to some degree baiting technique, is a more critical factor in minimizing deep ingestion than are hook size or appendage modifications, especially with larger turtles. Since the hooks were modified to remove the barb, their potential as circle hooks to prevent ingestion cannot be evaluated here.

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## **MINIMISING FISHERIES IMPACTS ON MARINE TURTLES – THE QUEENSLAND EXPERIENCE\***

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In Australia, the Queensland Department of Primary Industries and Fisheries has been working with the fishing industry over the last 15 years to implement changes to fishing practices to reduce the impact of fishing on marine turtles while at the same time making fishing operations more efficient. This paper provides a case study of the Queensland experience and describes how industry was engaged through education, extension and management activities to change the way commercial fishing is undertaken in the Trawl, Net and Crab fisheries. The Queensland East Coast Trawl fishery consisted of approximately 850 licences in the mid 1990’s. The fishery extends from the tip of Cape York in the north to the Queensland and New South Wales border and operates in the Great Barrier Reef World Heritage Area. The fishery in the mid 1990’s had significant impacts on marine turtles with high levels of interactions resulting in marine turtle deaths through drowning. The government worked closely with industry to develop a multi-tiered approach to addressing the problem. Turtle Exclusion Devices (TEDs) were made compulsory in the fishery, areas were closed at certain time when major nesting beaches were active and fishers were educated about how to resuscitate turtles if they were inadvertently caught. The number of licences in the fishery has also been reduced to around 400. Data collected on marine turtle strandings demonstrates that changes to management have been effective at reducing interactions, with the trawl fishery now considered to have only a negligible impact on marine turtles. Interactions with turtles also occur in the Queensland gill net and tunnel net fisheries. In many cases, turtles have become accustomed to the apparatus and regularly visit shots to feed. To minimise turtle mortality, the net fishery has adopted strict attendance rules and, for the tunnel net fishery, have incorporated TED’s into the tunnel apparatus. While the level of interaction remains high, turtles are able to easily swim through the TED and are released unharmed. Finally in the Crab Pot Fishery incidental mortality of turtles occurs through entanglement with ropes and with the pot itself when turtles investigate the bait. The government and industry have been working together to improve crab pot design and reduce the opening size of pots to allow crabs access but to keep out turtles. “Witches hats”, or inverted dillies, which have been linked to a number of interactions and ghost fishing issues due to their lighter construction, are being prohibited. By working with industry the Queensland government has demonstrated that the incidence of marine turtle mortality can be significantly reduced without impacting on the efficiency of commercial fishing operations, in some cases actually improving efficiency through behaviour and gear modification.

## **IMPACT OF INGESTED MARINE RUBBISH ON STRANDED SEA TURTLES SOURCED FROM SOUTH-EASTERN QUEENSLAND, AUSTRALIA\***

**Kathy A. Townsend**

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Gut impaction is a clinically recognised condition that affects many species of domesticated and wild reptiles, including water dragons, fresh water turtles, snakes and sea turtles. Ingested foreign objects can cause paralysis of the gut, inhibiting the digestion processes, potentially puncturing the gut lining, causing peritonitis, ileus, septicaemia or in some cases prolapse of the cloaca. In a domestic situation, inappropriate bedding and food have been linked to the condition and if caught early can be affectively treated. Alternatively, this same condition is much more chronic for wild sea turtles, with gradual weight loss, loss of buoyancy control, lethargy, constipation, dehydration, anorexia over several months and ultimately death. Information is available on the ingestion of marine debris by sea turtles in other parts of the world but currently no peer reviewed information is available on the impact of the ingestion of marine debris on turtles found in Australian waters. This study aims to address this lack of information. The impact of ingested marine debris on two species of sea turtles (*Chelonia mydas* and *Eretmochelys imbricata*) was examined. Specimens were sourced from individuals found stranded within the coastal waters extending from 27°37'S 153°21'E to 26°36'S 153° 08'E, in south-eastern Queensland, Australia. Animals were either dead when found washed up on shore or perished after rehabilitation attempts. Necropsies were performed on over 60 individuals and cause of death determined when possible using gross anatomical observations. Over 40% of green and 33% of hawksbill turtles were found to have ingested quantities of marine rubbish that impeded biological functions and was a major contributor to cause of death. While an additional 2-3% of animals had inconsequential amounts of marine rubbish in their guts, rubbish was not found in the guts of all the animals examined. Of the inorganic material sourced from the turtle guts, over 50% was from flexible, film like plastics (e.g. plastic bags and cling film), significantly more than the proportion surveyed of rubbish washed up on surrounding beaches, initially supporting the hypothesis that the turtles may be targeting this material due to the similarity the material has to jellyfish suspended in the water column. Ingestion of marine rubbish as secondary causal factor in sea turtle deaths and the implication of regionalised impacts are discussed.

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## **DEVELOPING A SEA TURTLE HUMAN INTERACTION ASSESSMENT PROTOCOL FOR STRANDED SEA TURTLES IN THE US**

**Lisa Wright, Mark Swingle, Gwen Lockhart, Christina Trapani, and Susan Barco**

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The Virginia Aquarium Stranding Response Program (VAQS) has developed a draft human interaction (HI) assessment protocol for stranded sea turtles and is seeking input from sea turtle stranding responders and researchers during the testing process. The protocol and associated datasheet have been designed to lead a responder through an external and internal examination of a stranded sea turtle and to objectively and consistently document findings of human interaction and general body condition. The protocol/datasheet includes an external examination to focus on vessel (including dredge) and fishery interactions and an internal examination that focuses on debris and gear ingestion, as well as evidence of internal tissue reaction(s) associated with pre- and/or peri-mortem trauma. We are seeking input on types of lesions seen in stranded sea turtles, both from HI and from natural causes, and on easily understandable definitions and characteristics that most accurately describe observed lesions. We have presented the datasheet and protocol at the Northeast Region Stranding Meeting and the Sea Turtle Stranding and Salvage Network State Coordinator's Meeting in the United States. When complete, the new protocol will be used to collect consistent data to document where problems between sea turtles and human activities occur. Development of the protocol by VAQS is phase one of a project supported by NOAA Fisheries Service Northeast Regional Office. After incorporating feedback into the completed HI assessment protocol, we will seek funding for phase two – the development of a training program for US stranding network responders. With continued support, the final protocol/datasheet and training program could eventually be shared with international audiences.

## **SUCCESS AND CHALLENGES OF TRANSFORMING THE INDONESIA TUNA LONGLINE INDUSTRIES ON REDUCING SEA TURTLE BYCATCH\***

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As a maritime country with abundance fisheries resources and large fishing fleets, Indonesia is urged to manage the fisheries resources responsibly. Besides, Indonesia provides important nesting and foraging grounds to many species and is home to the largest rookery for green turtles recorded in Southeast Asia, as well as the largest nesting rookery for leatherback turtles. Indonesia also represents important migration routes as the cross-roads of the Pacific and Indian Oceans. There are ± 1,600 tuna longline fleets based and operating in Indonesian waters. This means there are billions of hooks from tuna longline in the Indonesian waters every year. It causes sea turtles to be at risk of getting caught as bycatch in tuna longline in Indonesia. Since 2005, WWF-Indonesia has facilitated efforts to mitigate sea turtle bycatch, which included an assessment of the occurrence of by-catch; collaboration with the government, research institutions, NGOs and industry to train crews in proper turtle release techniques; initiation of an observer program and trial modification of long-line gear with different circle hooks. The onboard observer data collected between 2006-2007 show that from 18 vessels, 1,092 settings, 1,669,757 hooks a total of 132 sea turtles were caught. Based on their hook rate of 0.265 per 1000 hooks, the fleets from Bitung-North Sulawesi caught most turtles. Pelabuhan Ratu-West Java with 0.034 takes second position and Benoa-Bali with 0.030 takes the third position. All species of turtle known to migrate in Indonesian waters have been reported captured by tuna longline, with olive ridleys dominating the turtle bycatch and 4 leatherbacks being reported entangled in their gear. Fishermen didn't think it was a large problem, but considering the size of the fleet, it results in a large number of interactions throughout the year. In combination with the observer program, a gear trial was initiated for the tuna long-line industry to see if turtle hook-up rates would be lower when circle hooks were used. In the beginning, there were big challenges trying to engage fishermen in the trial. Many fishermen doubted whether they would catch any fish and comments included: (1) The circle hook size is too big compared with their hook, (2) Their bait is too small for the circle hooks. They are afraid that their bait will fall off in the water, (3) They don't trust the new hooks to catch as much fish as the old. During December 2006 up to February 2008, the trial was done with 18 vessels that based in Benoa-Bali, 51 Trips, 1,026 settings, 1,678,788 hooks. The aim of trial was to promote the effectiveness of circle hooks (C16/10) as compared to the traditional J-hooks in catching the target catch and reducing sea turtle bycatch. The results are promising. The use of circle hooks reduced bycatch of sea turtles by 78% and resulted in good fish catches. Up until August 2008 there are 34 tuna longline vessels using 38,800 circle hooks. The demand for circle hooks is increasing. However, There is very limited supply of circle hooks in Indonesia, and it is becoming a big challenge for WWF with more and more tuna vessels requesting it.

## **ENVIRONMENTAL IMPACTS**

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### **A CASE STUDY: HEAVY METALS AT RAS AL HADD GREEN TURTLE RESERVE AREA, SULTANATE OF OMAN**

**Salim H. Al-Rawahy, Mahmoud Ibrahim, Abdulaziz AlKindi, and Khamis Al Dhafri**

Sultan Qaboos University, Sultanate of Oman.

The purpose of this study is to identify the level of heavy metal contamination in sea water and sand samples at Ras Al Hadd, green turtle reserve area. A total of 12 heavy metals were determined using ICP analytical methods. Samples were collected randomly from different beaches at Ras Al-Hadd for the period of three years. There were significant differences ( $P < 0.05$ ) between sea water and sand samples, being higher in sand samples for all metals except Se. The levels of Cd, Co, Cr, Hg, Mn, Ni, Se and V in sea water samples were comparable to other regions. However, the concentrations of Cu, Pb, Sn and Zn were significantly higher as compared to the results obtained elsewhere. In both

sea water and sand samples, the concentration of Zn was the highest. Up to date, there are no other previous studies on heavy metals on the nesting beach sand that could be used as background comparison. The occurrence of heavy metals in sand samples at Ras Al Hadd may be attributed to accumulation of materials derived from sea water during high tides, direct anthropogenic activities and/or airborne deposits. This determination of pollution levels in sea and coastal environments is a critical part of bio-monitoring studies. Development of industrial areas in Oman coastal cities and rapid growth of population in recent years plus effluent discharges from many cities across Arabian Sea may have contributed to the presence of higher levels of some heavy metals in this area.

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## HIGHEST CAPTURES OF SEA TURTLES ASSOCIATED WITH ENSO EVENTS AT SAN ANDRES PORT, SOUTHERN PERU\*

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<sup>1</sup> ACOREMA

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Data is presented here as a review of records of sea turtles caught in coastal gillnet artisanal fishery at San Andres Port (13°45'S 76°15' W), Pisco, Southern Peru. Green turtles, *Chelonia mydas*, and leatherback, *Dermochelys coriacea*, composed the majority of catch; they were used for meat trade and human consumption. Also olive ridley, *Lepidochelys olivacea*, and hawksbill turtle, *Eretmochelys imbricata*, were captured. The raw data were collected from official statistics, literature review, sea turtles landed and surveys of beach and dumpsites. Statistical official records were collected since 1965 and 1985 by governmental agencies and include all species of sea turtle grouped in metric tons, more detailed data were provided at the early and late of 80's with new research focused on sea turtles. Although official catch data was not rigorously collected, data serve us to show a trend of sea turtles capture and compare with recent years. It is important to note that years with great captures were associated with ENSO events; in addition other factor as economical, play an important role for increasing sea turtles landed, for example after the collapse of anchovy fishery fleet at 1972. Monthly sea turtle captures are presented for 1987, significant correlations were found with ENSO (positive) and IOS (negative) indexes for this year. Also food availability with leatherbacks and green turtles were positively correlated, due mainly to the extremely high abundances of the Scyphomedusae, *Chrysaora plocamia* at that time. Analysis of biological data showed decrease of CCL of sea turtles among years. Green, showed a CCL of 68.50 cm ±2.5 in 1960 and in 2005 CCL, was 53.95 ± 8.94 cm. Besides leatherback showed a CCL =117 ±10.65 cm, for 1987 and CCL=109.27 ± 14.4 cm for 2005. We suggest that the smaller CCL recorded for both species could be an indicator of overexploitation due to systematic and sustained harvests that this area supported, mainly during ENSO years. Because sea turtles increase their abundance in coastal waters due to environmental variability and jellyfish availability derived from ENSO, are more likely to get entangled in gillnets. Even though sea turtles were protected in Peru since 1977, surveys still indicated ongoing capture and trade of green turtle and a seasonality capture of leatherback. For this, is urgent to schedule protective effective measures to mitigate sea turtle capture, even more when environmental changes factors are taking place more frequently. We gratefully acknowledge travel support from Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund).

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## USING GIS TO QUANTIFY THE EFFECTS OF SEA-LEVEL RISE ON MARINE TURTLE NESTING HABITAT

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Climate change is a major threat to wildlife, habitats and human populations. The manifestation of climate change is predicted to include rising sea levels, bleached coral reefs, higher temperatures, changes in sea-surface currents and greater storm intensity, all of which have the potential to negatively affect sea turtles. In a project by MacArthur

Foundation and WWF, marine turtles are being used as an indicator of how much climate change might affect coastal habitats. One aspect of this project is quantifying the potential loss of sea turtle nesting habitat to sea-level rise. Many factors, both natural physical and anthropogenic features, affect an area's vulnerability to sea-level rise. A GIS model is being used to collate the best available information on factors influencing vulnerability, which, when combined with different sea-level rise scenarios and nesting locations, can be used to identify which nesting beaches are most, and least, likely to be affected in Florida and the Caribbean.

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## **PRESENCE OF INORGANIC MATERIALS EXPELLED BY *CARETTA CARETTA***

**Daniela Freggi and Maristella D'Addario**

WWF Sea Turtle Rescue Center of Lampedusa

One of the principal threats to sea turtles is anthropogenic debris in our seas that are mistaken for food and often ingested by turtles, causing their death. In WWF Sea Turtle Rescue Center of Lampedusa, we have observed defecations of 200 hospitalized animals, from January to December 2008. Almost 100 turtles have expelled inorganic materials, that have been listed according to their origin, and we have pointed our attention on materials correlated to human activities and on the frequency of these material occurrences in turtles. We distinguished materials according to their composition: wood, plastic, metal and paper and we correlated them to the animal dimensions and season of recovery. Our preliminary study shows a strong interaction between turtles and materials unloaded in the seas. It could be interesting to improve an international contest, considering the peculiarity of the Mediterranean Sea. Projects shared between international partners could give an index of impact of anthropogenic debris on endangered marine species.

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## **COMMUNITY ASSISTANCE TO DETERMINE THE POTENTIAL AFFECTS OF PROJECTED SEA LEVEL RISE TO MARINE TURTLES**

**Mariana MPB Fuentes<sup>1</sup>, Colin J. Limpus<sup>2</sup>, Mark Hamann<sup>1</sup>, and John Dawson<sup>1</sup>**

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Projected sea level rise (SLR) is expected to cause shoreline erosion, saline intrusion into the water table and inundation and flooding of beaches and coastal areas. Areas most vulnerable to these physical impacts include small, tropical low-lying islands, which are usually key habitats for threatened and endemic species, such as marine turtles. Successful conservation of threatened species relies upon the ability of managers to understand current threats and to quantify and mitigate future impacts to these species. Therefore, we investigated the impacts of SLR to eight different rookeries in Australia, representing 99% of nesting activity for the nGBR green turtle population, the largest green turtle population in the world. For this, we developed 3-D elevation models from beach profiles and applied four sea level rise (SLR) scenarios projected by the IPCC 2007. To accomplish such task community involvement was a key component. Beach profiles and morphological data were collected from staff and volunteers from Earthwatch, Mer and Erub community. Results indicate that up to 38% of available nesting area across all the rookeries may be inundated as a result of SLR. Flooding will increase egg mortality and loss of nesting area at these rookeries affecting the overall reproductive success of the northern Great Barrier Reef (nGBR) green turtle population. This study provides a full understanding of how a genetic stock (management unit) will be affected to SLR aiding managers to prioritize conservation efforts and to use realistic measures to mitigate potential SLR threats to the nGBR green turtle population.

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## **ASSESSING THE VULNERABILITY OF KEY SEA TURTLE ROOKERIES TO PREDICTED GEOGRAPHIC SHIFTS IN CYCLONE ACTIVITY\***

**Mariana MPB Fuentes<sup>1</sup>, Col J Limpus<sup>2</sup>, Mark Hamann<sup>1</sup>, and James M. Moloney<sup>1</sup>**

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Given the predicted intensification of cyclone activities and a projection of a shift in the main cyclone genesis it is expected that impacts, caused by cyclones, to marine turtles will change. Therefore, it is important to understand the extent that marine turtle nesting grounds (rookeries) will be exposed to cyclones as climate change progresses and what factors influence their vulnerability to these extreme weather events. Therefore, we investigated the exposure of key rookeries used by four different marine turtle species (which comprises seven genetically distinct populations), in eastern Australia, under current projection scenarios for 2070. Current climatic scenario for the Australian region predicts that there will be a poleward shift in the main cyclone genesis as climate change progresses. For comparative purposes, historical (1960- 2000) exposure of each rookery and the overall exposure of each population to cyclonic activity was also investigated. Vulnerability to cyclones was assessed in relation to the spatial distribution of turtle's nesting areas and timing of their nesting season. Historically, nesting grounds utilized by the Coral Sea and marine turtle populations nesting in southern eastern Australia, such as the southern Great Barrier Reef (sGBR) green turtle and eastern Australian (EAL) loggerhead populations have been the most exposed to cyclonic activities. If the projected shift in cyclone location occurs, exposure to the sGBR green, EAL loggerhead and eastern Australian (EAF) flatback populations will increase and exposure to the hawksbill, northern Great Barrier Reef (nGBR) green and Gulf of Carpentaria (GCF) flatback populations will decrease by 2070. Vulnerability was found to vary within and between populations according to the spatial location of turtle's nesting and timing of nesting season. The information provided by this study is important since re-building resilience to the most vulnerable marine turtle populations may require the protection of the most functional nesting areas as climate change progresses.

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## **A PROGRESS REPORT: NECROPSY STUDY ON THE NORTHERN OUTER BANKS OF NORTH CAROLINA**

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The location and management of nesting sea turtles on the Outer Banks of North Carolina have been monitored for 30 years through efforts of state and federal agencies, as well as non-profit organizations. Along the northern beaches extending from Oregon Inlet to the North Carolina/Virginia State line, limited resources led to minimal data collection on dead strandings. Only 6.22% of potentially eligible turtles were necropsied annually. In 2007, The NC Aquarium at Roanoke Island (NCARI), the North Carolina Wildlife Resources Commission (NCWRC), and the Network for Endangered Sea Turtles (NEST) began pooling their efforts with a common goal of increasing necropsies on eligible dead sea turtle strandings to 100% on the northern Outer Banks of North Carolina. In 2008, Cape Hatteras National Seashore (CAHA) joined the study, more than doubling the study area from 57 to approximately 131 miles. Data of particular interest were sources of human interaction, sex ratios, and size classes. Four species were examined through strandings: loggerhead, green, Kemp's ridley, and leatherback. Most strandings encountered were moderately to severely decomposed, categories 2 and 3. An attempt was made to necropsy all category 2's and 3's whenever decomposition was not too severe. Over 76% of potentially eligible turtles had necropsy examinations performed. Lack of manpower, environmental factors or mutilation prevented us from reaching our goal of 100%. As presented last year, this study has also continued to provide educational opportunities that promote the issues surrounding sea turtle management and conservation. In an area renowned for its fishing and recreational boating, human interaction as the potential cause of death (entanglement or watercraft related) was of great importance to the study. In the first months of the study, May to December 2007, 29% of the 54 turtles necropsied showed evidence of watercraft or entanglement

wounds that were considered the cause of death. Since the start of 2008, when CAHA joined the study, the number dropped to 7% with a sample size of 100 turtles necropsied. Additional causes of death since the beginning of the study, May 2007, have included disease (4 cases) and mutilation (1 case). The vast majority of the necropsies led to an undetermined cause of death. Through these necropsies we have found identifying sex ratios to be challenging because of decomposition levels and immaturity of specimens. Based on the specimens that could be identified, 2007 data showed 22% male and 27% female. Sex was undetermined for 51% of all species. 2008 presented ratios of 25% male and 31% female, although 44% were undetermined. Sex ratio data were somewhat inconclusive, however the data differ from previously published findings of 2:1 female to male sex ratio along the Atlantic Coast. Looking at the sizes we hoped to gain some insight into what ages were found in this population of sea turtles. All the greens found were immature; the loggerheads included immature individuals above 51.2 cm maximum straight carapace length as well as mature specimens; the majority of Kemp's were immature; and leatherbacks were too decomposed to get size measurements.

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## **TORSOOI PROJECT: REGIONAL DATABASE AND GIS FOR THE CONSERVATION OF SEA TURTLES AND THEIR HABITATS IN THE SOUTHWEST INDIAN OCEAN**

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The Southwest Indian Ocean (SWIO) is an important nesting and feeding ground for marine turtles. Since 1972 surveys have been conducted to improve the knowledge regarding distribution, abundance, general biology, and behaviour of these migratory and endangered species. Surveys were initiated by IFREMER but since 1997 are also conducted by Kelonia. Unfortunately these surveys were often carried out independently of each other, following different protocols. Consequently, the incompatibility of data collected does not allow for a regional assessment of the status of marine turtles, which is necessary to define priorities for a global conservation strategy. To build collaborations and facilitate the exchange of data within the framework of marine turtle and habitat conservation in the SWIO, Kelonia and IFREMER, in association with the University of Reunion Island, initiated the TORSOOI program. This program aims to develop management and communication tools that are sustainable and adapted to the regional context and specific issues for these species. It will specifically establish the following: - A common online database, designed to centralise and standardise field data and protocols. This will enable data management and analyses on a regional scale. It will also provide data exchange, while enabling contributors to retain ownership over their data and credit for their work - A GIS database at multiple scales (regional and local), designed to manage habitat information and field data (distribution, abundance, migration, etc) for spatial analyses and mapping. This database will contribute to the identification of hot spots and priority areas for marine turtle conservation. The development of these systems will insure a compatibility with other existing systems by using web services to facilitate information exchange. Short-term objective is to centralise available data on marine turtles and facilitate information exchange by developing a strong partnership between research teams of the region. This is a pre-requisite for a first diagnosis regarding the conservation status of marine turtles within participating countries. In the long term, this project aims to develop partnerships with a greater number of countries within the region to establish a regional database. This expansion will standardise and, therefore, optimise data collection within the region. Consequently, this will enable a realistic regional view concerning the conservation status of marine turtles and will provide results required for the implementation of conservation measures. This project is co-supported by the European Union, which is committed to Reunion Island through the European Regional Development Fund (ERDF), Région Réunion, and the French National Research Agency (ANR).

## **SEA TURTLE RESEARCH AND CONSERVATION IN BANGLADESH WITH SPECIAL REFERENCE TO FEEDING HABITAT AND ECOLOGY**

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This paper deals with the feeding habitat and ecological status together with the existing research, conservation and management activities of sea turtles in Bangladesh coastal water. There is very little existing scientific research on the ecology and feeding habitat of sea turtle in Bangladesh coastal waters in publication, apart from a few reports from NGO's working in the region. The coastline of Bangladesh supports five species of sea turtles; the green turtle (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*). These sea turtles can be observed at Saint Martin's Island situated on the south-east tip of Bangladesh near Myanmar. This Island has important seagrass beds with species *Halophila decipiens* and *Halodule pinifolia* alongside shallow coral reefs, which offers suitable habitat for feeding and breeding of sea turtles. Habitat destruction, unregulated extraction and over-exploitation of these essential sea turtle habitats, from anthropogenic activities (especially sedimentation, land erosion and tourism) beyond carrying capacity are the major threats to the sea turtles in this region. The management and conservation of these habitats on the Island are poor. The destruction of habitat and over-exploitation of these resources have resulted in declining sea turtle numbers as well as degradation of coastal and Island ecosystems. To address these issues a long term monitoring and integrated research on ecology, feeding habitat and abundance of the five sea turtle species is needed to develop a sustainable long-term conservation and management plan on sea turtle resources in Bangladesh.

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## **LIGHTING THE WAY: HATCHLING ORIENTATION ON RUSHIKULYA MASS NESTING BEACH, INDIA\***

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Sea turtle hatchlings use visual cues of illumination and landward silhouettes during sea finding. Therefore sea finding is disrupted by artificial coastal lighting. The olive ridley turtle (*Lepidochelys olivacea*) that nests along the east coast of India faces threats from artificial lighting due to industrial development along key nesting beaches. Already, disorientation due to electric lights along nesting beaches is reported as being the major cause for hatchling mortality. Despite the species being placed in Schedule I of the Wildlife (Protection) Act, 1972 (the highest degree of protection afforded to a species by law in the country), there have been no attempts to modify coastal lighting or use light barriers, in order to decrease hatchling disorientation. We undertook the first study addressing the response of olive ridley hatchlings to light along the Indian coast. Using choice experiments and a light proof arena, we investigated the responses of hatchlings to different bands of wavelength and intensities of artificial light. Hatchling reactivity to light increased with intensity for each band of wavelength except for light in the violet region. Hatchlings were also positively phototactile for most bands of wavelength, but were relatively indifferent to light in the red region of the spectrum. We examined hatchling response to different lighting regimes along the beach, as caused by differentially spaced *Casuarina equisetifolia* plantations, highways and habitation. A mixed age plantation at a distance of not more than 100 m at its closest point proved to be an effective light barrier, preventing artificial light from falling on the beach, although it did not block out the glow in the sky. Hatchlings seemed not to be disoriented in such areas, and a significant number moved seaward (expected normal orientation). Hatchlings showed similar levels of disorientation to intense concentrated point sources of light and glows of light above the *Casuarina* plantations framing the horizon. The findings from our study suggest that *Casuarina* plantations could be a cheap and effective means of blocking light along extensive coastlines; however, plantations of exotics such as *Casuarina* could potentially disrupt beach dynamics as well as nesting behaviour of adult turtles. We also found that olive ridley hatchlings respond differently to certain

wavelengths and intensities of light, suggesting that authorities could modify the coastal light regime to reduce hatchling disorientation.

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## **AMONG YEAR VARIATIONS AND EFFECT OF CYCLONES ON SAND TEMPERATURES AT SEA TURTLE NESTING BEACHES IN WESTERN AUSTRALIA**

**Gerald Kuchling**

Chelonia Enterprises, Subiaco, Western Australia

I measured sand temperatures in four hour intervals at major mainland and island sea turtle nesting beaches from Coral Bay in the south to just north of Broome in Western Australia throughout the sea turtle breeding seasons of 2004/05, 2005/06 and 2006/07. Depending on beach profiles and the area used by sea turtles for nesting I deployed one logger at 50 cm depth just above the high water line where the lowest nests are found and a second 50 cm deep logger plus one at 10 cm depth near the highest nests at the dune crests. Although there are temperature differences between sites low and high at the beaches, seasonal and among year variations are much more pronounced than those across the nesting beach profiles. Sand temperatures increase during the start of the peak nesting season and highest sand temperatures (> 30°C) are generally measured in February and March. No major cyclone passed through the study area in 2004/05, but several in 2005/06 and 2006/07. During and after cyclones or cyclonic rains sand temperatures drop down significantly and may potentially change sex ratios of embryos which are just in their temperature sensitive periods. At some beaches dramatic beach erosions or massive sand depositions can occur during cyclones. The results indicate spatial and temporal (seasonal and among years) sand temperature variations which may influence sex ratios at major sea turtle nesting beaches in Western Australia. The long-term continuation of the program at some selected recording sites will also allow the evaluation of potential climate change impacts on sex ratios.

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## **LONG-TERM EVALUATION OF LOGGERHEAD SEA TURTLE NESTING BEACH TEMPERATURES IN THE SOUTHEASTERN U.S.: IMPLICATIONS OF GLOBAL CLIMATE CHANGE ON SEA TURTLE CONSERVATION**

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Loggerheads possess temperature-dependent sex determination (TSD) which has implications for their reproductive ecology and conservation. The Intergovernmental Panel on Climate Change (IPCC) indicates that global surface

temperature has significantly increased during the last century. The impact of global warming on species with TSD is uncertain. One of the world's largest loggerhead populations occurs in the southeastern United States. The current study is an ongoing, long-term evaluation of nesting beach temperatures throughout the range of loggerheads in the southeastern U.S. During the last five years beach temperatures were simultaneously examined from South Carolina to Alabama (including 23 nesting beaches in Florida) using data loggers buried at mid-nest depth (40 cm). The results reveal the range of beach temperatures throughout the population and provide insight on hatchling sex ratios. Overall beach temperatures suggested female-biased sex ratios. The temperature data were examined relative to previously published data on the pivotal temperature and transitional range of temperatures (TRT) for loggerheads. The results suggest many beach temperatures are above the pivotal temperature and some are at or near the upper limit of the TRT. Although loggerheads may be able to adapt behaviorally or physiologically to increased environmental temperatures, future increases in nesting beach temperatures could result in extreme female biases, as well as temperature-induced mortality. (This research was supported by the Florida Sea Turtle License Plate Grant Program).

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## **EFFECTS OF CLIMATE CHANGE ON SEA TURTLES: A SUMMARY FOR REGULATORY APPLICATION**

**Kimberly Maison**

NOAA Fisheries Pacific Islands Regional Office

The effects of climate change on protected marine resources must be considered and incorporated into the analysis of impacts of Federal actions on threatened and endangered sea turtles via consultations under Section 7 of the Endangered Species Act (ESA). The three areas of analysis required under Section 7 of the ESA where climate change should be considered include the environmental baseline (past and present impacts of all state, Federal or private actions and other human activities in the action area), current status and trends for each affected species (including current threats), and cumulative effects (the effects of future, non-Federal actions that are reasonably certain to occur in the action area). A literature review summarizing the major aspects of sea turtle biology and behavior that may be impacted by climate change is presented. The summary is intended for the use of NOAA Fisheries resource managers in the Pacific Islands Region (and elsewhere) to acknowledge the effects climate change may have on sea turtles in the context of other anthropogenic impacts while making management decisions affecting sea turtles. The five most direct effects discussed include: 1) changes in hatchling sex ratios as species that exhibit temperature-dependent sex determination; 2) loss of nesting beach habitat due to sea level rise; 3) alterations to foraging habitats and prey resources; 4) changes in phenology and reproductive capacity that correlate with fluctuations in sea surface temperature (SST), and 5) potential changes in migratory pathways and range expansion.

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## **THE ACCUMULATION OF DRIFTWOOD ON THE BEACH DISTURB LEATHERBACK NESTING AND NEWBORN BEHAVIOUR AFFECTING REPRODUCTIVE SUCCESS**

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The absence of parental care in sea turtles makes nesting site selection crucial for reproductive success. Characteristics of beaches such as, the quality of the sand, slope, erosion, the presence of litter or pollution may affect the mobility of females, the incubation of eggs or access to the sea of newborns. In many tropical sea turtle nesting areas, deforestation and big storms lead to a multitude of organic waste, such as macroalgae, seeds, roots, trunks and branches, to accumulate on the beaches. This often leads to the formation of barriers parallel to the sea. During the reproductive season of 2007 we studied the effects of driftwood accumulation on the beaches in the Colombian Caribbean Sea. We focused on studying the effects of driftwood accumulation on the following: 1. Behavior of nesting female leatherback turtles (*Dermochelys coriacea*) 2. Location of their nests 3. Orientation of hatchlings. Empirical studies were combined with field experiments in which we manipulated the amount of driftwood. Areas with a lot of driftwood did not reduce

the rate of nesting, but driftwood increased the risk of flooding and erosion for the nesting closer to the water. The driftwood did not alter the time of election and oviposition site, but the females spent between 33% -42% more time in the camouflage of the nest. There were injuries especially in the wings, shell and eyes caused by interaction with driftwood during different stages of nesting. We experimentally found that the cleaning of various sectors of the beach, generated a significant trend to make nests in areas with lower risk of flooding or erosion by tides. The effect of the driftwood on the mortality of adult females has not been evident during the study, however for the offspring driftwood is a lethal barrier in many cases. The young invest at least between 25 - 64% more time to reach the sea in areas with only a bit of driftwood and 10% of the offspring were immobilized, increasing substantially the risk of predation and dehydration. This study demonstrates the strong link between impacts on terrestrial ecosystems (deforestation of tropical forests) and coastal ecosystems (decline in the breeding success of sea turtles). Reduction of organic litter on the beaches can foster reproductive success of sea turtles.

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## **CLIMATIC CHANGE AND CHANGES IN SEA TURTLE NESTING DISTRIBUTIONS\***

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Climatic change will presumably affect all sea turtle species, and recent evidence supports changes in both hatchling phenotype and the timing of nesting in relation to climatic conditions, at least in some species. However, studies on many other taxa predict that the actual distribution of animals will change; this could result in some species expanding their distribution, while others become more geographically restricted. Much less is known about how this will affect animals that use multiple habitats throughout their life cycle (e.g., both terrestrial and marine systems), and this issue has been completely neglected in sea turtles. Sea turtles range much more widely throughout aquatic environments than in the terrestrial habitats in which they nest, which are restricted to tropical and temperate areas. This restriction, along with the susceptibility of eggs to extreme incubation conditions, suggests that critical nesting areas may be vulnerable to climatic change. I used species distribution modelling techniques to map the present-day distribution of sea turtles nesting within the United States, and used estimates of future climatic change to determine whether these areas will remain suitable for nesting in the future. I was able to accurately predict the known-nesting distribution of three species: leatherback turtles (*Dermochelys coriacea*), green turtles (*Chelonia mydas*), and loggerhead turtles (*Caretta caretta*); and also separately for each of the four recognized genetic units of loggerhead turtles. Under the climate change scenario that I modelled (doubled CO<sub>2</sub> emissions by 2100), the area suitable for leatherback and green turtle nesting shrunk slightly, but was largely unaffected; however, the area suitable for loggerhead turtle nesting virtually disappeared, and both the smallest and largest populations were negatively affected. When I modelled each of the four genetically distinct loggerhead populations separately, two of the genetic units were predicted to have no suitable nesting habitat remaining at all. This extreme range contraction is due to nesting beach environments becoming much warmer and drier than those presently experienced. This finding suggests that under such conditions eggs will not be able to hatch in these areas (or that hatching success may be greatly reduced). Suitable nesting habitat of the most abundant sea turtle species within the United States may be severely threatened by the loss of climatically suitable nesting areas, while the two rarer species will likely suffer little loss of nesting areas. Unless sea turtles can adapt to changing climates, such that eggs can actually hatch under incubation conditions not currently experienced at known nesting beaches, the fate of loggerhead turtle nesting within the United States appears grim. The approach I used is readily transferable to other species and regions, provided that adequate data exist on known nesting areas. I thank the following organisations for funding my attendance at this conference: International Sea Turtle Society, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund).

## **PILOT STUDY OF *CARETTA CARETTA* NESTING BEACH SAND TEMPERATURE IN NEW CALEDONIA**

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Given today's concerns regarding climate change, can marine turtles survive the recently predicted rapid climate changes? This is particularly important given the role of nest temperatures for regulating marine turtle incubation. Recent mapping of *Caretta caretta* breeding in New Caledonia shows that they breed throughout the country. Nesting occurs on a series of dark (brown siliceous) sand beaches and a series of white (coralline and quartz) sand beaches. Studies elsewhere show that dark sand beaches are warmer and produce more female hatchlings than light coloured beaches in the same area. This pilot study tests for differences in sand temperature (T) at nest depth (50cm) on representative dark and light coloured *C. caretta* nesting beaches in Province Sud, New Caledonia using temperature data-loggers. Sand temperature was measured over January-July 2008 at la Roche Percée, Bourail, (brown sand) and Redika Island (white sand) at 30min intervals. The 6 month study included the latter half of the breeding season. Contrary to expectation, the brown sand beach was significantly cooler than the white sand beach (mean sand T<sub>brown</sub> = 25.81°C; T<sub>white</sub> = 26.31 °C). Sand temperature dropped below 25°C, a minimum temperature for successful incubation at both beaches in May. With these results, the study has been extended to record over 5 years to examine temporal variability at these same sites. Additional data-loggers will be deployed to investigate finer scale spatial variability.

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## **RELATIVE EXPOSURE INDEX: AN IMPORTANT FACTOR IN SEA TURTLE NESTING DISTRIBUTION\***

**Julia Santana Garcon, Alana Grech, James Moloney, and Mark Hamann**

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The threatened status of many sea turtle populations and their vulnerability to coastal development and predicted climate change emphasizes the importance of understanding the role of environmental factors in their distribution and ecological processes. The factors driving the distribution of sea turtle nesting sites at a broad spatial scale is poorly understood. We analyzed the relationship between nesting site distribution and the exposure of coastal areas to wind and wind-generated waves. To achieve this we developed a Relative Exposure Index (REI) for an extensive area in north-eastern Australia and compared values of the index of nesting sites of five different sea turtle species and randomly selected non-nesting sites. Although there are differences between species, the results show that sea turtles nest in areas of higher REI values suggesting that wind exposure is an important factor in the spatial distribution of sea turtle nesting sites, and it may also influence nest site selection in female turtles and/or the dispersal of hatchlings towards oceanic currents. The combination of our results with further research on other driving environmental factors, like oceanic currents, has the potential to allow for the identification and prediction of future nesting sites, for which conservation and management may become essential.

## **FORECASTING HATCHING SUCCESS IN AN INSULAR MARINE TURTLE ROOKERY\***

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Though much of marine turtle conservation focuses on nesting areas, the factors contributing to hatching rates require more understanding. Nest inundation, human disturbances, beach erosion, predators, and invasive vegetation are major influences to hatching that vary in space and time. We examine hatching rates in the Dry Tortugas National Park, an insular nesting rookery in the Florida Keys (USA). This rookery is isolated from many of the impacts affecting most areas in the southeastern United States and the Caribbean. Though more than 60,000 tourists visit the islands each year, the direct impacts from humans are limited and there are no mammal predators. Impacts from nest predators and tropical cyclones can be extreme, however. Here we develop a mechanistic model that relates cyclone intensity to hatching success and incorporates predators. Egg predators consist mainly of native ghost crabs (*Ocypode quadrata*) and exotic ants (*Solenopsis* spp, *Pheidole* sp) whose populations are dynamic. We find hurricanes incurring >2m storm surge destroy more than 90% of existing turtle nests, but also extirpate predacious ants on most islands. Tourist boats ferries exotic ants to the islands, however, allowing some islands to be re-colonized by predacious ants within a few years. Taken together, we can understand the contributions to hatching success from each source and understand them in their historical contexts.

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## **JAGUAR PREDATION OF MARINE TURTLES: MULTILATERAL THREATS TO FLAGSHIP SPECIES AND THE NECESSITY FOR HOLISTIC CONSERVATION**

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Few species are known to predate adult marine turtles and none are known to impact populations in any large number. As such, traditionally, predation of marine turtles has not been regarded as a major threat. However, in Tortuguero National Park (TNP), Costa Rica, jaguars are predated nesting female turtles in increasing numbers; from four documented cases in 1997, to a minimum of 146 individuals per annum. If the current trend continues, jaguars will become one of the largest local threats to these marine turtles, resulting in conflict of the management of two of the leading conservation flagships in the Americas. Jaguar predation of marine turtles has been consistently monitored on Tortuguero Beach from July 2005 and is ongoing. Data collected include biometrics of predated turtles, photographs of the carcasses and signs of jaguar predation. Location data, including GPS position, are recorded, all of which eliminate the possibility of double-counting. Each survey also documents the number of turtle-tracks and the presence or absence of jaguar tracks per half mile. During this study, numbers of predated turtles have risen from minimums of 74 to 146 per year. The complex drivers of this interaction have yet to be fully understood and we discuss the likelihood of several theories and their possible implications for managing threatened species that include a terrestrial predator and a marine prey. Several ideas have been proposed to explain this rapid predation increase, including the absence of potential prey species, increased hunting pressure, the increase in jaguar numbers locally, and the decrease in available habitat. A high variety of jaguar potential prey species have been documented in several areas of the National Park during the time of increased predation. Whilst we await a current jaguar population estimate, this impact, in conjunction with high levels of deforestation over the same period have lead to the relative isolation of TNP, likely limiting the ability of the local population to thrive. As deforestation of the terrestrial boundaries around TNP continues, suitable forest habitat becomes marginalised towards the coast. However, not only does habitat loss appear to fit with current spatial and temporal activities of the local jaguar population, many of the likely secondary factors arguably have the same root cause. Whilst this remains to be seen, factors negatively affecting jaguars, a highly

sensitive species affected by a range of invasive human activities, are indirectly affecting turtles, highlighting the importance of conserving holistically to the benefit of these keystone species.

## **FORAGING BIOLOGY**

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### **DISTRIBUTION OF HAWKSBILL TURTLES OFF PERU AND IMPLICATIONS FOR REGIONAL CONSERVATION EFFORTS**

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The hawksbill turtle, *Eretmochelys imbricata*, is considered Critically Endangered by the IUCN. However, information on this species in the East Pacific (EP) is scarce and recent concerted efforts to tackle the subject have been necessary ([www.propeninsula.org](http://www.propeninsula.org)). The lack of information is particularly true for the Southeast Pacific region (SEP) - an area where this species is known to occur in low numbers (both nesting and foraging) with the southern limit of distribution thought to occur in Peru. Here we summarize data gathered during sea turtle bycatch monitoring programs within Peruvian artisanal fisheries. From 2000-2008, we recorded hawksbill turtles as bycatch from fishing trips occurring in northern locations such as Caleta Grau (03°39'S, 80°38'W), Mancora (04°05'S, 81°04'W) and Constante (05°35'S, 80°50'W). We did not obtain any reports of bycatch from three other sampled ports in southern Peru, between 13°44'S and 18°00'S latitude. This information contrasts with previous research that reported this species off the central Peruvian coast, in Pisco (13°44'S, 76°14'W). The fishing gear used included purse seines, bottom set nets, driftnets and coastal rafts. Based upon capture locations we inferred that turtles preferred neritic waters (<200m) and were located close to shore (1.1-15nm). Bycatch of hawksbills was more frequent during the spring and summer and CCL ranged from 28.3 to 49cm (37.6 ± 1.65, n=14), suggesting that hawksbills inhabiting Peruvian waters may be mostly juveniles. Further studies such as genetics and analysis of foraging ecology would be useful within a regionally coordinated research and conservation program.

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### **FORAGING GROUNDS OF GORGONA (COLOMBIA) AND THEIR IMPORTANCE FOR GREEN SEA TURTLES (*CHELONIA MYDAS*) IN THE EAST PACIFIC\***

**Diego F. Amorocho and Richard D. Reina**

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Gorgona National Park plays an important role in the feeding and development of East Pacific green sea turtles. This 618 km<sup>2</sup> protected area, located 56 km off the Pacific coast, is the only place where the species occurs in Colombia. Mean curved carapace length (CCL) of 308 turtles measured between 2003 and 2007 was 61.3±7.9 cm (ranging from 40 to 80 cm). Mean mass was 27.1±9.5 kg (ranging from 7.5 to 64 kg). Esophageal lavages performed on 84 green

turtles showed an omnivorous diet, feeding on a range of animal and vegetal items. In contrast to the herbivorous diet of green turtles exhibited in other sites of the East Pacific, Gorgona's immature population fed mostly on animal matter with a bias towards tunicates. To better understand the nutritional contribution of the omnivorous diet, we investigated the true digestibility of dry matter, assuming that high digestibility in marine turtles corresponded to long digesta retention times. The mean Intake Passage Rate (IPR) of 9 turtles to release between 70–100% of marker beads under 3 different diet treatments: protein (fish), vegetal (fresh leaves of Araceae, Moraceae and Bombaceae) and mixed (combination of both high protein and vegetal diets) was  $23.3 \pm 7.16$  days. The mean percentages of organic matter ( $67.8\% \pm 4.3$ ), neutral detergent fiber ( $76.2\% \pm 4.40$ ), acid detergent fiber ( $55.8\% \pm 4.09$ ), lignin ( $27.7\% \pm 4.10$ ), protein ( $13.9\% \pm 2.02$ ), hemicellulose ( $20.3\% \pm 5.04$ ) and cellulose ( $27.9\% \pm 3.6$ ) contents were estimated from 150 collected fecal samples following standard procedures. The average nutritional value of protein (22%) and digestibility (65%) of consumed tunicates underline the importance of the Gorgonas National Park foraging grounds for green turtles of the East Pacific, to rest and gain energy for continuing their long distance migrations to other areas in the Pacific Ocean. We thank the Colombian National Parks System, NFWF, USFWS, NMFS, Rufford Small Grants, Conservation International, CIMAD, the University of West Indies, volunteers and the ISTS for the financial and logistic support. This research was conducted under permit DTSO 0029 from the Colombian National Parks, and ethics approval BSCI/2003/04 from Monash University. Special thanks to the ISTS, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), David and Lucille Packard Foundation, Sandler Family Foundation and Marisia Foundation, for the travel grant that allows for me to attend the 29th ISTS.

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## **HABITAT USE AND FOOD INTAKE OF GREEN TURTLES (*CHELONIA MYDAS*) FORAGING ON A MULTISPECIFIC SEAGRASS BED AT MAYOTTE ISLAND\***

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Seagrass beds are among the most productive ecosystems on earth and play a key role in marine environments. Among marine herbivores, green turtles (*Chelonia mydas*) consume significant amounts of the biomass within seagrass ecosystems. Green turtles in Mayotte forage predominantly in shallow, easily accessible coastal seagrass meadows, providing a unique opportunity to investigate their trophic ecology under natural conditions. In the literature, it has been proposed that herbivores compensate for the low energetic value of plants and their lack of essential dietary components by showing pronounced diet selectivity. Previous studies have reported multiple foraging strategies for green turtles, depending on trophic conditions and inter-specific interactions on monospecific seagrass or multispecific algae-seagrass beds. To assess the determinants of the foraging ecology of green turtles, we investigated the habitat use and the feeding behaviour of a population of green turtles on a multispecific seagrass meadow off Mayotte Island, Southwest Indian Ocean. Here, highly productive, biodiversity-rich and multispecific seagrass meadows are exploited throughout the year by green turtles of different age classes and sex. Inter-specific competition and predation of turtles at this location are limited. Our study is novel in that we combined an assessment of the phytoecology of a multispecific seagrass meadow with a fine scale investigation of the foraging behaviour of a mixed and free ranging green turtle population. The study defined the foraging habitat of green turtles as a phytosociologic system composed of 7 seagrass species (*Halodule uninervis*, *Syringodium isoetifolium*, *Halophila ovalis*, *Thalassia hemprichii*, *Cymodocea serrulata*, *Zostera capricorni* and *Thalassodendron ciliatum*), associated in four seagrass communities which occur along a depth gradient. The spatial distribution of green turtles occurred in accordance with species composition of the seagrass communities. Juvenile green turtles selected the most digestible seagrasses, *Syringodium isoetifolium* and *Halophila ovalis*, while adult green turtles consumed the most abundant seagrasses *Halodule uninervis* and *Syringodium isoetifolium*. From direct underwater observations of adult green turtles, we estimated their daily food intake at 262.4 gDW seagrass d<sup>-1</sup> turtle<sup>-1</sup>, consistent with previous studies. Green turtles adjusted their habitat use and their feeding behaviour according to their status and food availability. This might be explained by the potential differences in nutritional quality within the multispecific seagrass meadow and by the expected differences in food requirements among sea turtles. Our study is a crucial step towards the improvement of management and conservation plans for sensible ecosystems, such as seagrass meadows, and for critically endangered species such as sea turtles. Acknowledgements: The authors would like to thank the International Sea Turtle Society, Australian Government

DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation for generous donations supporting the participation in the 29th Annual Symposium on Sea Turtle Biology and Conservation.

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## DIET OF PELAGIC LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN SOUTHERN BRAZIL

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The coast of Rio Grande do Sul State is an important developmental ground for loggerhead sea turtles (*Caretta caretta*), a globally threatened species. The high productivity of this region sustains an intense fishing industry. Incidental catch and marine debris ingestion are the main causes of non-natural mortality of sea turtles in this region. The juvenile feeding grounds are very important to sea turtles and their diet has a direct influence on growth and reproduction. The aim of this study was to determine the diet of loggerhead turtles in southern Brazil. The gut contents of 8 individuals incidentally caught in pelagic longline fishery in southern Brazil were analyzed. Each animal was measured (curved carapace length-CCL) and the entire digestive tract was removed. Samples were washed, sorted in a sieve and preserved in 70% alcohol. Food items were identified to the lowest taxonomic level, and their importance in the diet presented as frequency of occurrence and relative volume was reported. Data on anthropogenic debris is shown as present/absent. The turtles sampled consisted of immature individuals and the curved carapace length ranged from 53-63 cm (mean=58.4). Anthropogenic debris was found in 87.5% of animals, which is higher than that reported in the literature. Sixteen taxa were identified: brown algae (*Macrocystis pyrifera* and *Sargassum* sp.), cnidarians (*Aequorea* sp.), crustaceans (Brachyurans, amphipods and *Lepas* sp.), mollusks (heteropods, pteropods and *Illex argentinus*) and tunicates (Pyrosomidae and Salpidae). Most important items were cnidarians (51.9%) and *I. argentinus* (33.1%). The cnidarian values may be underestimated, because much of their content was lost when frozen or placed in preservative. Cnidarians are not often considered as prey in food webs of marine ecosystems. In the central North Pacific, the most important prey item for pelagic loggerhead turtles was a species of heteropod (*Carinaria cithara*). This group was found in this study too, but to a much lesser extent (0.1% of volume). The most frequently occurring prey items were *I. argentinus*, present in 100% of samples, and *Cavolinia uncinata* (62.5%). *Illex argentinus* is used as bait in longline fisheries, which explains why it was found in 100% of the animals. It was observed that the turtles can take the bait from hooks without capture, since there were more than one squid in two stomach samples. Additionally, the presence of various items that float at the surface were recorded, such as plastics, feathers, pteropods, floating masses of algae or that which is associated with floating debris, such as *Lepas* sp., which is characteristic of an opportunistic diet.

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## UNDERWATER PHOTOGRAPHY AS A WINDOW INTO HAWKSBILL FORAGING BIOLOGY AND BEHAVIOUR

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In this study, images obtained from recreational underwater photographers offered an opportunity to enhance our understanding of the in-water ecology of hawksbill turtles. Turtles were photographically documented at a variety of depths, including those beyond the range of our capture efforts. Observations of foraging behaviors included feeding on sponges (particularly the leathery barrel sponges, *Geodia neptuni*), and scraping coral (a behavior which likely

represents feeding on encrusting sponges, invertebrates or algae). Occasional consumption of thimble jellyfish, *Linuche unguiculata*, was also documented. Intra- and inter-specific interactions were observed: a commensal feeding relationship was noted with grey, *Pomacanthus arcuatus*, French, *Pomacanthus paru*, and queen angelfish, *Holocanthus ciliaris*, and aggressive, possibly territorial, interactions between hawksbills were observed in high density habitat. Overall, photographs collected during this project offer insights into diet, habitat and behavior - highlighting the utility of this technique in the study of charismatic marine animals.

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## **SEA TURTLES IN THE GLOVER'S REEF MARINE RESERVE, BELIZE: CHARACTERISTICS AND CONSERVATION IMPLICATIONS**

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Belize has historically been an important place for sea turtles, with abundant foraging and nesting habitat for three species of sea turtles: greens, loggerheads and hawksbills. Sea turtle nesting populations throughout Belize have been severely depleted with only remnant populations remaining, and they continue to decline. The status of in-water populations has not previously been studied, although there are anecdotal reports. The Wildlife Conservation Society initiated an in-water study at Glover's Reef Marine Reserve (GRMR) in 2007. We report information on characteristics of each sea turtle species occurring at GRMR during two years of in-water mark-recapture efforts, and implications for sea turtles in the region.

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## **A STUDY OF THE HAWKSBILL (*ERETMOCHELYS IMBRICATA*) AND GREEN TURTLES (*CHELONIA MYDAS*) FORAGING ON THE REEFS OF TOBAGO, W.I.; DISTRIBUTION, ABUNDANCE AND AN ASSESSMENT OF THEIR VALUE\***

**Michelle Cazabon**

University of the West Indies, St. Augustine, Trinidad and Tobago and Turtle Village Trust, Trinidad and Tobago

Trinidad and Tobago are best known for the large nesting population of leatherbacks, but four other species of marine turtles have been reported on our beaches and in our waters. This is the first study carried out in Trinidad and Tobago to assess the population of turtles that inhabit our potentially important foraging ground reef habitats. Over a period of 15 months, 244 SCUBA dives (~192 hours) were completed on 44 dive sites scattered around Tobago. A total of 130 hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) were sighted, including 13 confirmed repeat sightings of tagged individuals. Hawksbill turtles were found on sites distributed all around the island, but were seen in markedly higher frequencies at a number of specific sites. The distribution of green turtles on reefs was more limited, with a total of 19 greens observed across just 9 dive sites. Turtles ranging in straight carapace length from 15 to 100 cm were seen, a range encompassing juveniles, sub-adults and sexually mature adults. A total of 6 greens and 50 hawksbills were caught and tagged, and 5 tagged hawksbills were recaptured. Fifty-five tissue samples were collected for mtDNA analysis to identify the origin of Tobago's turtles (results pending). Additionally, four fecal samples were collected from hawksbill turtles which will be used to determine preferred prey species. Apart from their ecological value by foraging on reefs and sea grass beds, both species have direct economic values through their consumptive use by fishers and indirect use by SCUBA divers. Regulations enacted in 1975 under Section 4 of Trinidad and Tobago's Fisheries Act specify an open season on capture of turtles at sea. An active, unregulated turtle fishery reportedly continues year round in Tobago. A survey was conducted to determine the extent of this turtle fishery, and to examine the value of turtles to fishers. The awareness and views of fishers on the laws, threats and abundances of turtles were also investigated. A total of 215 fishers were interviewed throughout Tobago and 22 reported that they fish for turtles.

Of these, 14 stated that they view turtles as an important source of income. Only 6 of the 22 stated that they restrict the catch of turtles to the open season. The value of live turtles to SCUBA divers in Tobago is being investigated using choice modeling—a stated preference technique for the economic valuation of non-market goods. Over 100 SCUBA divers completed the model questionnaire at dive shops scattered around Tobago. Results are pending, but the value of live turtles to SCUBA divers is expected to exceed the value to fishermen. The results of this study can influence local management decisions, including choosing critical habitat for protection, reviewing existing fisheries legislation and establishing regular monitoring sites.

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## **FORAGING ECOLOGY PATTERNS OF THE MOSQUITO LAGOON JUVENILE GREEN TURTLE (*CHELONIA MYDAS*) POPULATION FROM 1978 TO PRESENT: REFLECTIONS OF A HEALTHY SEAGRASS HABITAT?**

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Green turtles and loggerheads in the Indian River and Mosquito Lagoon were heavily exploited by commercial fisheries in the late 1800's and based on subsequent fishing efforts, both species experienced a population crash by the early 1920's. In 1978, the Atlantic green turtle (*Chelonia mydas*) was listed as endangered under the Endangered Species Act. From 1976 to 1979, researchers from University of Central Florida investigated the population status of marine turtles in Mosquito Lagoon, including foraging habits, movements, and behaviors of juvenile green turtles (*Chelonia mydas*). Two decades later, in 1994, researchers from Kennedy Space Center reinitiated the earlier study and have since gathered contributing data critical for the recovery of both loggerhead and green turtle populations. Many juvenile species take up residence for several years in estuarine ecosystems and depend on seagrass and associated fauna for food resources. Healthy seagrass ecosystems are vital to the successful recovery of marine turtles. The southern portion of Mosquito Lagoon is relatively undeveloped with seagrass beds showing historically similar percent cover and composition since the 1940's. The largest percent composition of submerged aquatic vegetation (SAV) in this often hypersaline lagoon is shoal grass (*Halodule wrightii*), while manatee grass (*Syringodium filiforme*), star grass (*Halophila engelmannii*) and widgeon grass (*Ruppia maritima*) comprise a much smaller percent of total seagrass. Most researchers report high seasonal and annual variation in SAV percent cover and composition that may influence the foraging habits of green turtles. However, a comparison of foraging samples from juvenile green turtles captured in Mosquito Lagoon over the last 32 years revealed no significant changes in foraging habits and similar SAV percent composition. These data are important in establishing the health and carrying capacity of ecosystems, as well as the status of historical developmental habitats for the recovery of marine turtle populations.

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## **FOOD HABITS OF JUVENILE GREEN SEA TURTLES (*CHELONIA MYDAS*) ALONG THE MIDDLE AND LOWER TEXAS COAST**

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Green sea turtles (*Chelonia mydas*) of the western Gulf of Mexico exhibit a complex feeding ecology initiated by post-hatchlings functioning as opportunistic carnivores in the pelagic zone. As developing juveniles, greens move into neritic habitats where they become primary herbivores foraging on algae and sea grasses. The Texas coast is an important developmental region for a growing juvenile green turtle population. Important foraging grounds for these juveniles are located in both the offshore and inshore areas of Texas' Laguna Madre and Coastal Bend region, where a 75% increase in human population has occurred over the last 40 years. In the offshore areas of the Texas coast, green turtles are reported to feed chiefly on algae, debris, and animal matter as they move into inshore habitat. Inshore habitat

of the state consists of sea grass beds, where in the lower Laguna Madre there is an exhibited tremendous growth in Turtle grass (*Thalassia testudinum*) and Manatee grass (*Syringodium filiforme*), while Shoal grass (*Halodule wrightii*) has decreased drastically. Although green turtles feed on all three species and have been historically shown to prefer shoal grass, the impact of changes in Texas' sea grass communities on juvenile foraging ecology has not been assessed. Due to an increasing growth of the green sea turtle assemblages of the middle and lower Texas coast, a greater understanding of how green sea turtles utilize the foraging habitats is necessary. The gastrointestinal tracts of 164 juvenile green turtles that stranded from the middle coastal bend region to the lower region of Texas during 1999 to 2008 were collected and frozen for examination. The geographic range of the stranded turtles includes the inshore and offshore areas of Aransas County to Cameron County. Seventy seven strandings were from inshore habitats and 87 were found offshore. The tracts were salvaged from fresh dead to moderately decomposed turtles. The stranded turtles had a straight carapace length that ranged from 15.4 cm to 69.6 cm, with an average length of 38.1 cm. The gastrointestinal tracts will be examined for taxonomic identification of food components, wet and dry mass of each food category, wet and dry volume of each food category, and location of food material in the tract. This study aims to identify food items consumed by juvenile green turtles, detect possible food preferences, and assess variations in their diet, especially in light of possible changes within foraging grounds. Research on this life history stage of green turtles will provide knowledge on the foraging habitat of green turtles, which will aid in conservation and management strategies for the species and the habitat it forages in. This research also intends to provide awareness on an increasingly growing population of juvenile green turtles.

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## **AERIAL SURVEYS OF MARINE TURTLES ALONG THE WEST COAST OF REUNION ISLAND**

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Since the end of the 20th century, marine turtles have been observed regularly in the waters around Reunion Island, Southwest Indian Ocean, where nesting activity declined significantly after human colonisation. An aerial survey program was initiated in 1996 to monitor the marine turtle population and their spatial distribution along the west coast of the island. Between 1998 and 2007, a total of 1,480 marine turtle sightings were recorded during 132 flights with ultra-light aircraft, which followed a coastline transect between Saint Leu and Saint Paul (30 km). We found that the mean number of turtle sightings per survey increased significantly between 1998 and 2007, while a large size range of marine turtles was recorded throughout the year. The latter could indicate a renewal of the population along the west coast of Reunion Island, where it finds suitable habitats for foraging and growing. Marine turtles were recorded preferentially in coral reef zones and on the outer reef slopes. Spatial distribution may be linked to the topography and substrate of the bottom, which determine the availability of food and shelter. Interestingly, the marine protected area located off Saint Paul seems beneficial to marine turtles as they preferentially frequent this area rather than other regions of the west coast. These results are encouraging for the preservation of marine turtles in Reunion and reflect the commitment of local organizations toward the conservation of sea turtles. The authors gratefully acknowledge the generous support of Région Réunion.

## **ABUNDANCE, SIZE CLASSES, GROWTH RATES, AND CONDITION OF FORAGING GREEN SEA TURTLES, *CHELONIA MYDAS*, AT JOHN BREWER'S BAY, ST. THOMAS, U.S. VIRGIN ISLANDS**

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Three species of sea turtles are commonly found around the United States Virgin Islands. Leatherback sea turtles (*Dermochelys coriacea*) migrate to nest primarily on St. Croix while green (*Chelonia mydas*) and hawksbill sea turtles (*Eretmochelys imbricata*) are observed year round throughout the territory. Nesting behaviors of all three species have been studied in several locations around St. Croix. However, few studies have been done to assess the foraging populations of sea turtles throughout the territory. The purpose of this study was to assess the foraging population of green sea turtles at John Brewer's Bay through an analysis of their abundance, size classes, growth rates, and general condition. Additionally, because Green Turtle Fibropapillomatosis has been detected on turtles in the Caribbean, including the nearby islands of Culebra and Vieques, Puerto Rico, the presence of the epithelial tumors on sampled turtles was also documented. Green sea turtles were captured, measured, examined, tagged, and released at John Brewer's Bay in June and December 2005 and in April, May, and August 2008. Tissue samples were collected for DNA analyses. Forty-eight green sea turtles have been caught (23 in 2005 and 25 in 2008). These green sea turtles range in size from 23.9 to 66.2 cm Straight Carapace Length Notch to Tip (SCLNT). The average size was 40.1 cm SCLNT and the adult:juvenile ratio was 7:41. The average size class varied by year with an average size of 41.6 (28.0-58.5) cm SCLNT recorded in 2005 and an average of 38.9 (23.9-66.2) cm SCLNT in 2008. The adult:juvenile ratio was 5:18 in 2005 and 2:23 in 2008. Five cases of recaptures were documented, including one green tagged in 2005 that was recaptured that same year, one tagged in 2005 and recaptured in 2008, and three 2008 greens recaptured throughout the same year. Those recaptured greens had an average growth rate of 0.582 cm SCLNT per month (ranging from 0.3 to 0.95 cm SCLNT per month). Growth rate was fastest in the 30.1 to 39.9 cm size class. John Brewer's Bay was described as a dynamic recruitment and foraging site in 2005, and a possible haven for turtles injured elsewhere around the island. Among the sampled green turtles were many with carapace damage (21 of 23), abnormal scute patterns (3), missing flippers (1) and hooks (1). One turtle exhibited strong physical characteristics of a green and hawksbill sea turtle (a possible hybrid). The sea turtles sampled in 2008 had far less damage to their carapaces, and only 1 had an abnormal scute pattern. Tumors associated with Green Turtle Fibropapillomatosis were observed on none of the sea turtles sampled in 2005 or 2008. More sampling is needed to better understand the foraging population of green sea turtles at John Brewer's Bay. Similarly, sampling throughout the territory's bays will be important in better understanding site fidelity, migratory patterns, and a general description of bay utilization.

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## **KEMP'S RIDLEY SEA TURTLES IN ST. JOSEPH BAY, FLORIDA, USA: RESULTS FROM AN IN-WATER STUDY IN THE NORTHEASTERN GULF OF MEXICO**

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It is well documented that the Gulf of Mexico provides essential habitat for the critically endangered Kemp's ridley turtle (*Lepidochelys kempii*). In recent years, scientists have recognized the need to conduct in-water studies to better understand the biology of sea turtles. Although studies have been conducted throughout the eastern Gulf, data are lacking from St. Joseph Bay, a temperate coastal embayment in northwest Florida. This Bay has recently been identified as an important neritic habitat for sea turtles in the northern Gulf of Mexico. The study occurred from May

2001 to June 2005, and resulted in 44 captures of 40 individual Kemp's ridley turtles. A total of 234.7 net-set hours resulted in 48 captures of 41 green turtles. All turtles were captured in the southern end of the Bay, in areas with seagrass beds (*Thalassia testudinum*) interspersed with sandy patches. Capture sites had depths ranging from 1.3 to 1.5 m (mean=1.4 m, SD=0.4, n=42) and sea surface temperatures ranging from 25.9 to 33.0°C (mean=29.5°C, SD=1.4, n=42). Mean annual Catch Per Unit Effort was calculated as 0.72 turtles captured/ km/ net soak hour. Although sampling occurred year round, turtles were net captured only during the months from April through October. Straight carapace length (SCL) of captures ranged from 29.6 to 49.5 cm SCL (mean=37.1 cm, SD=5.3, n=41) indicating that St. Joseph Bay is an important developmental area for immature Kemp's ridley turtles. Recapture rate (# turtles recaptured/ # turtles captured) was 14.6 %, with most turtles recaptured seasonally. Time at large, or recapture interval, ranged from 31 to 870 days (mean=389 d, SD=318, n=7), indicating some degree of residency similar to that of Kemp's ridley turtles in the eastern Gulf of Mexico. Although anecdotal reports and cold stunning events have documented the presence of Kemp's ridley turtles in this coastal habitat, this study is the first to report results on year round sampling using set netting and strike netting for this species in northwest Florida. Our results confirm previous findings that the size of Kemp's ridley turtles in the eastern Gulf of Mexico increases from north to south. The possibility of ontogenetic habitat shifts in juvenile Kemp's ridley turtles inhabiting nearshore waters of the Gulf of Mexico is examined.

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## STABLE ISOTOPE DICHOTOMY IN LOGGERHEAD TURTLES REVEALS PACIFIC-ATLANTIC OCEANOGRAPHIC DIFFERENCES\*

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Recently, differences in trophic information obtained from stable isotope analyses in leatherback turtles (*Dermochelys coriacea*) from the Pacific and Atlantic oceans revealed substantial differences in the nitrogen signature between ocean basins. This pattern was attributed to differences between ocean basins in their nitrogen cycling regimes. We evaluated whether a similar ocean basin dichotomy was evident in oceanic juvenile loggerhead turtles (*Caretta caretta*) by analyzing their stable isotope signatures in both the Pacific and Atlantic oceans. Skin samples from juvenile loggerheads were collected from Peru in the southeast Pacific from 2003-2007 and from the Azores in the northeast Atlantic from 2002-2003, and analyzed for nitrogen and carbon stable isotope ratios ( $\delta^{15}\text{N}$  and  $\delta^{13}\text{C}$ ). Our results confirm that  $\delta^{13}\text{C}$  signatures are similar between loggerheads in the two ocean basins, reflecting the oceanic feeding behavior (epipelagic) of these loggerhead populations. The  $\delta^{15}\text{N}$  signatures in Pacific loggerheads are consistently higher than those of Atlantic loggerheads. This inter-basin difference in  $\delta^{15}\text{N}$  values may reflect unique characteristics of the nitrogen cycle in each ocean basin which has an effect on the nitrogen composition at the base of the food web that is subsequently transmitted to higher trophic levels. The nitrogen dichotomy revealed in the new locations surveyed in this study suggests that this phenomenon occurs basin-wide. Further stable isotope analyses of inter-annual variations of our samples will provide insights on the relationship between changing oceanographic conditions and feeding behavior of loggerheads. Stable isotopes signatures in high trophic level organisms, such as oceanic sea turtles, can reveal differences in oceanographic processes.

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## DEMOGRAPHIC AND CONSERVATION IMPLICATIONS OF ALTERNATIVE FORAGING STRATEGIES IN JUVENILE LOGGERHEAD TURTLES\*

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Marine megafauna are especially vulnerable to depletion as a result of their slow life histories. Since they are long-lived, slow-growing, and late to reproduce, their population growth is sensitive to changes in growth, reproduction, and mortality of both large juveniles and adults. Despite the demographic importance of large juveniles, juvenile ecology and life history remains poorly understood in most species of large marine vertebrates. Delayed maturity and high mobility enable juvenile migratory megafauna to choose between broad ranges of habitats and foraging strategies. Such variation in foraging strategies and resulting vital rates in juvenile life stages may have profound implications for the demography and conservation of migratory megafauna. We compared diet and movement of juvenile loggerheads between habitats to evaluate potential demographic and conservation consequences of alternative juvenile foraging strategies. Forty-four juveniles that were satellite tracked from the Baja California peninsula, Mexico (BCP), occupied neritic habitat with utilization distributions two orders of magnitude smaller than twenty-six juveniles of the same size class tracked from the Central North Pacific. Speed, displacement, and straightness index of neritic foragers were all dramatically lower. Length frequencies of oceanic and neritic loggerheads showed broad overlap. Stomachs of eighty-three loggerheads beachcast at the BCP showed a diet consisting of fish and crustaceans in contrast to the poorer quality epipelagic prey consumed by oceanic juveniles. Differences in diet, movement and the overlap of length frequencies suggest that juvenile loggerheads can pursue distinct foraging strategies sustained over many years. Given published advantages in juvenile growth and adult fecundity of neritic foraging, sustained alternative strategies between juveniles probably confer broad variation in growth, size and age at maturity and eventual fecundity, with profound implications for the demography of loggerheads. If any one of these vital rates vary consistently between oceanic and neritic foraging juveniles, impacts on the trajectory of the endangered North Pacific loggerhead population would be profound. Our findings underscore the importance of elucidating variation in the ecology and corresponding vital rates of juveniles for modeling, managing and conserving migratory megafauna populations.

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## EFFECT OF FOOD RESOURCES AND SHELTER ON THE ABUNDANCE AND DISTRIBUTION OF HAWKSBILL TURTLES, *ERETMOCHELYS IMBRICATA*, IN CARIBBEAN CORAL REEFS

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While affinities for specific feeding and resting areas are known for some species of sea turtles, information on habitat features preferred by the hawksbill turtle (*Eretmochelys imbricata*) remain largely unknown. The identification of habitats used by hawksbill turtles and their critical features are needed to understand not only the distribution or population density, but also to determine which types of habitats are essential in protecting this endangered species. In this study, we related the abundance and spatial locations of either captures or sightings of juvenile hawksbill turtles in four reefs off of Culebra Island, Puerto Rico, to the natural abundance of food resources and shelter availability in these

reefs. Our hypothesis is that higher densities of hawksbill turtles will be found in reef areas with higher abundances of feeding items and shelter areas. Daytime snorkeling censuses were conducted at the four reef sites between April and December of 2008 to obtain the Capture per Unit Effort (CPUE), GPS locations of captured turtles and esophageal content samples. CPUE is used as an index of relative abundance of hawksbills. Captured turtles were brought on board the boat to be measured (maximum straight carapace length), tagged and released. Each site was surveyed for 8 hours during three days to capture a minimum of 10 turtles per site to collect diet samples by using the techniques from van Dam and Diez (1998) and Balazs (1980). To date we have collected diet samples (n=22) from 14 hawksbill turtles. Benthic surveys were carried out to quantify food availability as defined by the abundance of prey species and to measure rugosity as an index of shelter availability within areas where turtles were abundant and rare. We adapted the methodology of León and Bjørndal (2002) to quantify prey species availability and the contoured versus linear length of Risk (1972) modified by McCormick (1994) to measure rugosity. Preliminary results suggest high turtle spatial variability with areas in which turtles were consistently seen and captured, and other areas where turtles were rarely seen. The sponge *Chondrilla nucula* is the most important prey item for hawksbills in Culebra island ( $86.72 \pm 28.09\%$  average esophageal content, n=17 samples). A Kruskal-Wallis One-way Analysis of Variance of prey abundance shows that there are no significant differences of percent cover of *C. nucula* between the high and low turtle density sites (Mann-Whitney U Test Statistic = 137.000; p-value: 0.609). Even though there are no significant differences of the surface rugosity index between the high and low hawksbill density sites (Mann-Whitney U Test Statistic: 198.500; p-value: 0.104), more turtles were seen and captured at sites with high rugosity. In conclusion, our data suggests that the abundance and distribution of juvenile hawksbill turtles is more related to the distribution and abundance of shelter areas than to food resources.

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## **ABUNDANCE ESTIMATES AND HABITAT PREFERENCES FOR LOGGERHEAD TURTLE (*CARETTA CARETTA*) OFF SOUTHERN SPAIN: IMPLICATIONS FOR CONSERVATION\***

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The western Mediterranean is a critical foraging habitat for the loggerhead turtle (*Caretta caretta*). Thousands of juvenile and sub-adult loggerheads originating from nesting areas along the east coast of the U.S. congregate in pelagic habitats year round. Almost fifty per cent of the turtles found in the western Mediterranean foraging grounds originated in nesting beaches along the East Coast of the U.S., most of them from the South Florida subpopulation. More recent studies reveal that more than 90% of the turtles off the North African coast and south of the Balearic Islands belong to Atlantic stocks. The estimated residence time of the Atlantic loggerheads in the Mediterranean is approximately ten years. The Southwest Mediterranean Sea is considered one of the main hotspots worldwide in terms of loggerhead turtle fisheries bycatch. Estimates of annual bycatch of loggerheads by the Spanish longline fleet ranged from 1,953 turtles in 1993 to over 35,000 in 1990. The population size of loggerhead turtles inhabiting the Western Mediterranean basin and, more specifically, the Alboran Sea, is calculated using non-systematic ship-based line transects conducted during the period of June 1992 to August 2008. A model-based approach is used for estimating abundance since the survey design did not achieve equal coverage probability. Line transect sampling is combined with spatial analysis to estimate the abundance of loggerhead turtles and explore the factors influencing such abundance and habitat use. Sizes and life stages of the turtles are compared with previous studies and the impact of bycatch to the life stage is discussed. Results from the abundance estimation of loggerhead turtles in the area can help to assess the impact of the fisheries bycatch on the populations.

## **SIZE DISTRIBUTION OF GREEN TURTLES (*CHELONIA MYDAS*) FOUND AROUND THE COAST OF JAPAN INDICATED FROM BYCATCH AND STRANDING DATA**

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Green turtles are found in the feeding grounds off the coast of Japan. However, size distributions and migration patterns are poorly understood. In this study, we analyzed straight carapace lengths (SCL) of 1,211 green turtles from the coastal waters of Japan. Of these, 490 turtles were from stranding records gathered by the Sea Turtle Association of Japan. The remaining turtles were caught in pound nets in Nomaike (western Kyushu) and Muroto (south eastern Shikoku). The SCL measurements from all three sites ranged from 54–1,097 mm and the histograms (each size class divided by 100 mm) indicated two peaks in size classes: 401-500 mm and 701-800 mm. Turtles 501-600 mm seem to disappear from the coastal waters of Japan. There are two hypotheses to explain the absence of this size class. Firstly, the number of hatchlings was small or the death rate was substantially high (e.g. due to a contagious disease). Secondly, turtles of this size class may migrate to other waters. Two other green turtle studies showed similar peaks indicating that green turtles in the size class of 501- 600 mm were scarce: one in Okinawa (1996-1999) and one in Wakayama (19 years ago). Therefore, we rejected the first hypothesis and are further considering the second hypothesis. It is likely that green turtles of 501 - 600 mm SCL stay away from the coastal waters of Japan for some reason and consequently disappear into the “second lost year”. Collaborative migratory research is needed with neighboring countries such as Taiwan, China and the Philippines.

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## **AGE AND GROWTH RATES FOR HAWAIIAN HAWKSBILLS USING SKELETOCHRONOLOGY**

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Skeletochronology, the technique of studying growth marks in the bones of reptiles and amphibians, has been used to determine age and growth rates in all sea turtle species except for the flatback and the hawksbill. The Hawaiian hawksbill population is very small with generally fewer than 20 females nesting per year, hence there is a need to monitor this population closely and basic biological parameters of individual growth rates and estimates of age to maturity are critical. Here we present the first skeletochronology analysis of hawksbill humeri. Humeri were recovered from dead stranded turtles throughout the main Hawaiian Islands by the Sea Turtle Stranding and Salvage Network of the NOAA/NMFS/Pacific Islands Fisheries Science Center, Marine Turtle Research Program. To date, 27 humeri have been collected and processed for skeletochronology analysis. The sizes of the turtles range from 26.2–83.8 cm SCL, covering a full ontogenetic series from recruitment into the nearshore habitats to adult. In addition, 20 dead hatchling turtles have been recovered from nests to give baseline information for the growth curve. Similar to what has been observed in other sea turtle species, there is a strong linear relationship between carapace length and the diameter of the humerus ( $r^2 = 0.98$ ,  $P < 0.05$ ), demonstrating a proportional relationship between bone dimensions and body size. This allows for the estimation of carapace lengths using growth marks within the bone, leading to estimates of growth rates. Growth mark morphology shows readily distinguishable marks that are more diffuse in appearance than those observed in more temperate species. For similar sized animals, there is considerably less resorption of the interior region of the bone (and the earlier growth marks) than what has been observed in leatherbacks, loggerheads, Kemp's ridleys and greens, indicative of a denser bone in hawksbills and allowing for much more complete records of growth. Preliminary results suggest that hawksbills have faster growth rates than either loggerheads or greens, and given their smaller size at maturity (~80 cm SCL), potentially indicates a lower age to maturity for hawksbills than the 35-50 yrs generally estimated for the other large hardshell sea turtles.

## **LIGHTS, CAMERA, ACTION: UTILIZING A PHOTOGRAPHIC CATALOG AS A TOOL FOR THE IDENTIFICATION OF HAWKSBILL SEA TURTLES**

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Photo-identification has proven effective in many field studies, particularly in marine mammal research. More recently, similar techniques have been applied to other marine species, including fish and sea turtles. A photographic catalog of ninety two turtles was created as a tool to identify individuals in a Floridian (USA) population of hawksbill turtles (*Eretmochelys imbricata*). To test the effectiveness of the catalog, a survey was administered to 237 naïve non-science major college students. Ten photographs of unknown turtles were to be matched against a pilot key of twenty known turtles. Survey instructions were modified to test if the presence of a central scale between the postocular and tympanic scales is a significant factor in achieving individual turtle identification. Central scales were recorded in 47% of the ninety-two catalogued turtles (left side of head only), and were present in seven of the ten unknown survey turtles. With a central scale present, correct identification was achieved in 43% of the trials. If the central scale was absent, correct identification occurred 37% of the time, representing a significant decrease in reliability ( $P < 0.0001$ ). These results support the hypothesis that the presence of the central scale is a useful starting point for differentiating hawksbill turtles. We conclude that photo-identification is a limited but plausible method for recognizing individuals in a hawksbill turtle aggregation.

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## **MULTI-YEAR OBSERVATIONS OF GREEN TURTLES (*CHELONIA MYDAS*) IN A NEARSHORE HARDBOTTOM HABITAT OF PALM BEACH ISLAND, FLORIDA, USA**

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Young green turtles are attracted to the shallow hardbottom habitats of Florida's southeast coast. However, the inherent difficulties associated with in-water surveys have limited our ability to document the abundance and movements of these wide-ranging marine vertebrates, even in areas that are relatively close to shore. This report summarizes five years of year-round snorkel surveys that were conducted on the nearshore hardbottom reefs of central Palm Beach Island, Florida. Six hundred and ninety green turtle sightings were recorded during two hundred sixty three surveys. When possible, photographs and GPS positions were taken when turtles were encountered. Twenty-four green turtles have been encountered repeatedly, several over the course of 12 months or more, often in close proximity to the original sighting location. A marked increase in green turtle sightings since 2006 suggests a growing abundance of green turtles in this area. Our extremely limited knowledge of the abundance of this and other endangered marine turtle species in Florida's nearshore habitats urges us to strongly advocate the implementation of additional in-water sea turtle monitoring programs.

## **AGE AND GROWTH OF LOGGERHEAD TURTLE FROM COASTAL SOUTH CAROLINA ESTIMATED FROM MARK-RECAPTURE DATA**

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Populations of loggerhead turtles (*Caretta caretta*) have been in jeopardy as the result of a variety of anthropogenic impacts. Loggerhead turtles are circumglobal and the causes of the worldwide decline are due to several factors ranging from the harvesting of adult turtles or eggs, habitat destruction of nesting sites and degradation of marine environment, to trawl fishing mortality. Loggerhead populations have declined from historic levels by more than 50%, making it an endangered species. Assessing loggerhead populations has been difficult because determining the age of living turtles has been problematic. In this study, we estimate the age and growth of loggerhead turtles from mark-recapture data. Loggerhead turtles (N=937) caught as by-catch on commercial and experimental fishing vessels were measured (notch to notch carapace length (CL)), marked and released. Upon recapture (N = 18), tag number, CL (cm) and time at large were recorded. Twelve of the recaptured individuals (60%) showed evidence of tag loss, revealing tag retention issues. These turtles were marked between March 30 and July 9, 1998. The recaptures of these loggerheads occurred between June 6, 2000 and July 15, 2003. The initial CL of the recaptured turtles ranged from 53.7 cm to 97.4 cm. Final CL for the recaptured turtles ranged from 54.6 cm to 97.9 cm. The time between mark and recapture ranged from 62 days to 1,544 days. Measured growth ranged from 0.1 cm to 6.8 cm. The von Bertalanffy growth equation parameters  $L_{\infty}$  and  $k$  were calculated using an iterative method developed by Fabens. We estimate  $L_{\infty} = 88.04$  (95% C.I.=80.55–95.55) and  $k=0.0845$  (95% C.I.=0.0671-0.1020). We used an arbitrary  $t_0 = 0$ , as this parameter can not be estimated from this method. Based on our model, we estimated the age range of loggerhead turtles in our population was 21–60 years. We conclude that carapace length measurements from captured and recaptured individuals provide a viable method of estimating age and growth of loggerhead turtles.

## **GENETICS AND STOCK RECOGNITION**

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### **MOLECULAR GENETIC LINK OF GREEN SEA TURTLES (*CHELONIA MYDAS*) FROM DERAWAN ISLANDS-INDONESIA WITH AUSTRALASIAN POPULATION\***

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We were interested in investigating the genetic composition and diversity of the green sea turtle aggregations from Derawan Islands to elucidate the genetic connectivity established between these aggregations (i.e. nesting and foraging) and the Sulu Sulawesi Marine Ecoregion (SSME) as a result of green sea turtles dispersal and migratory behaviour. For

this purpose we analyzed the genetic variation in the mitochondrial DNA control region from the Pulau Panjang aggregation (n=51) and compared with the genetic composition of the nesting aggregations of Sangalaki, Derawan and Blambangan (n=38) and previously assessed Australasian nesting grounds. After analysis of approximately 740bp of the mtDNA we identified 36 polymorphic sites (35 transitions and 1 transversion) that determined 11 different haplotypes that included three variants of haplotypes C3, two of C5, and two of haplotype D2. Molecular diversity estimates of all samples indicated a high haplotype and nucleotide diversity ( $h=0.853 \pm 0.014$ ;  $\pi=0.01098 \pm 0.01009$ ). High haplotype and nucleotide diversities were also found in nesting samples ( $h=7$ ;  $hd=0.778 \pm 0.045$ ;  $\pi=0.00381 \pm 0.01083$ ) as well as in feeding ground samples ( $h=10$ ;  $hd=0.845 \pm 0.028$ ;  $\pi=0.01535 \pm 0.01104$ ). The genetic composition of the nesting aggregations were dominated by haplotype C3 (39.47%) followed by haplotypes C14 (18.42%) and C5 (18.42%). Although haplotype C3 is common most of the nesting aggregations in Australasia, the genetic composition of the nesting aggregations from Derawan Islands is more similar to the rookeries of Malaysia, which are also composed by the combination of haplotypes C3, C5 and C14. The Pulau Panjang feeding ground was dominated by haplotype D2 (29.41%), D2A (19.61%), and A3 (13.73%) and results from mixed stock analysis suggest a genetic connectivity of the Derawan foraging aggregations with nesting grounds from Malaysia and Philippines. In addition, the Pulau Panjang feeding ground also seems to be home for Micronesian and Papua New Guinea nesting turtle populations, dominated by the presence of haplotype A3 and A4.

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## GENETIC DIVERSITY OF THE GREEN TURTLE (*CHELONIA MYDAS*) POPULATIONS IN SRI LANKA

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During the last few decades, marine turtle populations have been declining rapidly throughout the world, due to human interruption. They face many threats all around the world including slaughtering for meat and collecting eggs for human consumption. All seven species of marine turtles, including green turtles (*Chelonia mydas*), are listed as endangered or critically endangered by the IUCN. Although marine turtles are protected by government legislation, turtles are still being exploited in Sri Lanka. Population decline may cause the reduction in genetic variation of the turtle population. A relatively new thought based on evolutionary theory has argued that conservation efforts should focus on preservation of the genetic diversity that allows species to respond to changes and adapt for new conditions. The genetic diversity is widely believed as a base for the organismal diversity. Therefore, conservation projects are heading towards safeguarding genetic variation. The objective of this study is to determine the genetic diversity of the green turtle population that nest on southern coast of Sri Lanka. Small skin samples were collected from the nesting green turtles at Kosgoda turtle rookery, and preserved in 95% ethanol. Genomic DNA was extracted by chelex protocol. Microsatellites were amplified from genomic DNA by polymerase chain reaction (PCR). Six primers, Cm3, Cm58, Cm72, Cm84, Cc117 and Cc7 were used for the analysis. The PCR products were separated by polyacrylamide gel electrophoresis (PAGE) and the genetic diversity of the population was determined. Authors acknowledge the financial support from National Science Foundation, Sri Lanka (Grant Number: SIDA/2005/BT/01) and International Foundation for Science, Sweden (Grant number A/3863-1). Also we wish to acknowledge to symposium travel committee and to the Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund) for the travel grant.

## **STANDARDIZING THE MTDNA CONTROL REGION FRAGMENT FOR SEA TURTLES: HOW LONG DO SEQUENCES NEED TO BE?**

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Sequencing the control region of mitochondrial DNA has proven to be a very useful tool for determining population structure in marine turtles. Most published studies have used a relatively short fragment (300-400 base pairs) of control region DNA to identify marine turtle population structure. In recent years many laboratories have begun amplifying longer mtDNA fragments (700-900 base pairs) that include and extend beyond the previously common fragment. This longer fragment has uncovered additional genetic variability that has enabled finer scale resolution of population structure. However, the variable lengths of sequences generated by different laboratories make it hard to compare haplotypes from different studies. In order to facilitate collaboration with other labs, we found that it would be helpful to define a standard cropping site that is useful for sequence alignment in all species of marine turtles. Our criteria for this cropping site included finding a conserved region across species, retaining all intra-specific as well as inter-specific variation, and shortening the fragment as much as possible so that everyone regardless of varying technology could easily generate the fragment. We looked at six of the seven species of marine turtles, across ocean basins, not including the flatback, and found a conserved region that is between 763 and 781 base pairs that we propose as a standard for future sea turtle mtDNA sequencing of the control region. This sequence fragment should be further examined with additional data for all geographic areas in all species to confirm that there are no additional variable sites.

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## **POPULATION STRUCTURE OF OLIVE RIDLEY SEA TURTLE (*LEPIDOCHELYS OLIVACEA*) IN THE ATLANTIC OCEAN USING MICROSATELLITE MARKERS\***

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The olive ridley sea turtle (*Lepidochelys olivacea*) is widespread in tropical and subtropical oceans being the most abundant sea turtle. In the Atlantic Ocean, this species has limited distribution and nesting has been reported mainly in Guinea Bissau, Surinam, French Guiana and north-eastern Brazil. While Guinea-Bissau, Surinam and French Guiana nesting populations have been declining in the past decades, the Brazilian population had a 10-fold increase in 11 years. Little is known about genetic diversity and structure of the olive ridley in the Atlantic Ocean. The Atlantic Ocean populations surveyed to date had low mtDNA diversity, with only three haplotypes (E, F and a new one F-1), suggesting these populations may be isolated from the others. This hypothesis needs to be tested with other markers so to better contribute to the management and conservation of these populations. Here we present partial results on the genetic diversity and population structure of olive ridley populations of Guinea-Bissau, Surinam and Brazil using microsatellite loci. Eight microsatellite loci were genotyped in 61 individuals from Guinea-Bissau (n=5), Surinam (n=8) and north-eastern Brazil (n=48). Molecular diversity indices, Hardy-Weinberg equilibrium, linkage disequilibrium analyses and population structure were assessed with Arlequin 3.11 (AMOVA) and Structure 2.2 software. The mean expected heterozygosity was  $H = 0.67$  for Surinam,  $H = 0.56$  for Guinea-Bissau and  $H = 0.62$  for Brazil. Heterozygosity per locus varied from 0.40 to 0.89 with average of 0.61. After Bonferroni's correction for multiple comparisons, all loci were in Hardy-Weinberg equilibrium and there was no evidence of linkage disequilibrium. AMOVA and Structure software did not show significant population structure among Surinam, Guinea-

Bissau and Brazil ( $F_{st} = -0.03$ ). While sample size limits our initial conclusions, these results may be explained by high migration rates between nesting beaches or recent colonization of the Atlantic Ocean with no time for population differentiation. Although these results are preliminary and should be interpreted with caution, they corroborate the absence of significant differentiation found with mtDNA data. We are increasing the number of individuals from Surinam and Guinea-Bissau and the number of loci to better understand of genetic structure and diversity of the olive ridley in the Atlantic Ocean. Acknowledgments: We gratefully acknowledge for support the International Sea Turtle Symposium, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), David and Lucille Packard Foundation, Sandler Family Foundation and Marisla Foundation.

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## LOW MTDNA DIVERSITY OF THE BRAZILIAN NESTING POPULATIONS OF OLIVE RIDLEY TURTLES (*LEPIDOCHELYS OLIVACEA*)

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The olive ridley turtle (*Lepidochelys olivacea*), has a circumtropical distribution and it is considered to be the world's most abundant sea turtle. It is classified as "Vulnerable" by IUCN Red List of Endangered Species. Conservation projects, like Tamar-Ibama in Brazil, have been allowed major protection for marine turtles; however these animals are still threatened by fishery activities, nest destruction and pollution. Previous studies with mtDNA shown that populations from the Atlantic Ocean present very low haplotype diversity, with only two haplotypes (E and F) found so far. The olive ridley nesting population in Brazil is relatively small, Sergipe being the main nesting area although it also occurs in Northern Bahia. Here we estimate the mtDNA control region variability of the olive ridley from Brazil and compare it with other nesting populations. Were analyzed 74 samples from individuals from Sergipe (n=63) and Northern Bahia (n=11) collected in the Tamar Project base. Two haplotypes were found, haplotypes F previously reported for the Brazilian nesting population, and a new one, F-1 which differs from F by a single base insertion. Haplotype F was observed in 70 (97.22%) individuals, while haplotype F-1 was observed in two (2.77%) individuals. This result corroborates the extremely low genetic variability of the mtDNA for the olive ridley Brazilian population. In contrast with other oceanic basins, haplotypes found in Atlantic populations have not been found in other ocean basins indicating that these populations may be isolated from the others. Acknowledgments: We gratefully acknowledge for support the International Sea Turtle Symposium, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), David and Lucille Packard Foundation, Sandler Family Foundation and Marisla Foundation.

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## NEW INSIGHTS INTO THE COMPOSITION OF GREEN TURTLE FEEDING GROUNDS IN THE NORTHERN GREAT BARRIER REEF\*

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Effective conservation management of green turtle (*Chelonia mydas*) populations in Australia requires knowledge of the breeding stock composition of multiple foraging populations throughout the region. For the Torres Strait in the

northern Great Barrier Reef (nGBR), this knowledge is needed to better understand the potential impacts from harvests that include turtles taken during the breeding season and resident turtles taken from the foraging grounds. Additionally, there is concern over a possible low recruitment rate into the nGBR population from the Raine Island rookery this needs to be assessed. Using Mixed Stock Analysis (MSA) we calculated the relative proportion of genetically differentiated nesting populations represented at two of the major feeding grounds for green turtles in the nGBR, Torres Strait and the Howicks group of islands. The MSA reflected a large difference in the haplotype composition between juveniles and adult turtles for the two feeding grounds, with a high proportion of the adults coming from the nearby nGBR stock. This result was not surprising and is supported by the prevalence of tags from the nGBR breeding population recovered from harvested and resident turtles. However, results from the resident juvenile population show a clear difference in the relative contribution of turtles originating from the nGBR. Among the juvenile turtles, there is an increase in the contribution of rookeries other than the nGBR, particularly from the southern GBR and possibly also from the Coral Sea, Papua New Guinea, Berau Island, and the North West Shelf in Western Australia. However, the surprising result is the large reduced contribution from the nGBR stock in the resident juvenile population in relation to the adult turtles. Here we discuss two possible explanations for the observed pattern. First, that juveniles may be using developmental habitats such that they shift to foraging grounds closer to their breeding grounds as they mature. Secondly, that the observed difference may be due to a severe reduction in the number of new recruits coming from the nGBR rookeries for more than a decade. While there is no direct evidence for this hypothesis it is strongly supported by the severe reduction in hatchling production observed from Raine Island during the past decade or more. Raine Island is one of the largest green turtle rookeries in the world and substantial declines in production from this rookery would be expected to have observable effects.

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## **EVALUATION OF DNA EXTRACTION METHODS ON SEA TURTLE TISSUE: HOW MUCH DO WE NEED BEFORE SACRIFICING QUALITY OVER QUANTITY?**

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Molecular techniques have been increasingly applied to a variety of research questions. Early marine turtle genetic studies primarily addressed evolution, taxonomy and phylogeography. These studies often involved a relatively small number of animals, but required a reasonably large quantity of tissue for DNA extraction. More recently, genetic studies have been directed at resolving fine scale population structure which requires gathering genetic information from a large number of animals. Advances in laboratory techniques have greatly improved our ability to acquire DNA from small quantities of skin, organs, bone or drops of blood. However, optimal samples need to be large enough to yield DNA of sufficient quality and quantity to reliably carry out multiple analyses with a variety of markers, and yet small enough to minimize trauma to the animal. We describe the high throughput techniques that are currently used at the NOAA-Fisheries, Southwest Fisheries Science center, Marine Turtle Genetics Laboratory and evaluate the current skin sampling protocol to address the question that is commonly asked by field biologists: "how much skin do you need for genetic analysis?" Within the last decade our lab has progressed from using DNA extraction methods such as phenol-chloroform (PC) and DNEasy extraction kits to robotics in order to obtain DNA from sea turtle tissue and blood samples. Methods like PC and DNEasy are labor-intensive and pose a health threat due to the toxic chemicals required in the protocol. Using robotics with high-throughput methods (HTR) allows large batches to be processed efficiently, with minimal health risks, and better cost-effectiveness. However, there is some concern that the DNA obtained from our HTR methods might not be as concentrated as DNA from the old PC and DNEasy methods. To determine if DNA quality is sacrificed using HTR techniques, we compared the concentration of DNA (ul/ng) extracted from sea turtle skin using older extraction techniques versus the HTR method. We found that HTR yielded lower concentrations of DNA but higher quantities. These yields are sufficient to consistently produce reliable results for mtDNA sequencing, microsatellite and single nucleotide polymorphism (SNP) analysis. We conclude that the 3-6mm skin biopsies that are routinely collected for sea turtle studies are adequate to carry out genetic analysis with HTR methods.

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## **STOCK ORIGIN OF LEATHERBACKS (*DERMOCHELYS CORIACEA*) FORAGING OFF CENTRAL CALIFORNIA, USA**

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Genetic studies have been instrumental in identifying stock structure and phylogeography of sea turtle populations around the world. Off the Central California coast in the United States, NOAA-Fisheries' Southwest Fisheries Science Center has been conducting in-water research on foraging leatherbacks (*Dermochelys coriacea*) to determine nesting origin, foraging ecology, migration patterns and diving behavior of these animals. In this study we use molecular genetics and Bayesian statistical approaches to estimate the stock composition of this foraging population. A total of 48 tissue samples were collected from leatherbacks foraging in Monterey Bay and waters off the San Mateo coast in central California between 2000-2008. DNA was isolated from each sample and 800 base pairs of the mitochondrial control region were sequenced. The haplotype frequencies were compared with data from potential source populations to estimate the stock composition of the foraging aggregation using mixed stock analysis (MSA). All haplotypes matched those identified among western Pacific nesting populations, indicating that this northeastern Pacific foraging aggregation is part of the western Pacific breeding stock. This study is consistent with satellite telemetry studies that have recently documented migrations between foraging areas off the US west coast and nesting beaches in Indonesia and Solomon Islands. The results have important fisheries management and conservation implications across the Pacific.

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## **RE-EXAMINING CARIBBEAN HAWKSBILL POPULATION STRUCTURE USING LONGER MTDNA SEQUENCES**

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Samples collected from seven Caribbean hawksbill (*Eretmochelys imbricata*) nesting sites were analyzed with new primers that expand the mitochondrial DNA (mtDNA) control region sequence length from 380-480bp to 800bp to determine whether new genetic variation could be uncovered and if it provides better resolution for detecting genetic population structuring. Data from six of the nesting sites (Antigua, Barbados, Costa Rica, Mexico, Puerto Rico, and USVI) have previously been published at the shorter length. An additional major new rookery from Nicaragua, which has not previously been surveyed, was included to re-examine stock structure of hawksbills in the Caribbean. Additional variation with the longer sequences was detected which identified eighteen polymorphic sites that resolved a total of 16 haplotypes, including six new variants of haplotypes previously described by shorter sequences. Four haplotypes identified in earlier studies were not detected, indicating likely errors based on older sequencing techniques. Preliminary findings suggest that use of the longer sequences improve resolution for population structuring. The additional variation will advance our ability to determine stock contributions for management purposes. We recommend use of the 800bp fragment described as a minimum standard for future mtDNA surveys for hawksbills, and the haplotypes we have identified provide a basis for standardizing future work.

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## **NATAL ORIGIN OF JUVENILE LOGGERHEAD TURTLES FROM FORAGING GROUNDS IN NICARAGUA AND PANAMA WITH NEWLY SUGGESTED MITOCHONDRIAL DNA PRIMERS**

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Our study estimates the natal origins of juvenile loggerhead turtles (*Caretta caretta*) in coastal waters of Caribbean Nicaragua and Panama using a Bayesian mixed stock analysis. The analysis is based on newly suggested mitochondrial DNA dloop primers (LCM15382/H950 and LTEi9/H950), which amplify about 880 base-pairs. These primers are designed to target longer mtDNA sequences because shorter primers (TCR5 and TCR6) do not provide the necessary resolution to categorize haplotype frequencies. For our project, we estimated natal origins from 74 blood or tissue samples of juvenile loggerhead turtles captured in foraging habitats in Caribbean Nicaragua. In addition, we reanalyzed 45 juvenile loggerhead blood samples from the Caribbean coast of Panama with new mtDNA primers to test the accuracy of previously published estimations. Further, we compared the stock composition between Nicaragua and Panama foraging aggregations. These two locations are not geographically distant, but do encompass different ocean current patterns. Thus, we compared the effect of ocean currents on the recruitment, migration patterns of juvenile loggerhead turtles, and tested the theory of juvenile loggerhead turtle homing to foraging habitats. Analyzing longer mtDNA fragments will increase precision of estimation of the natal origins of juvenile loggerhead turtles and their homing behavior. Furthermore, comparison of two geographically separate foraging grounds allows us to accurately analyze specific juvenile migration patterns with strong statistical power.

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## **INCREASED GENETIC VARIATION UNCOVERED IN LOGGERHEAD TURTLES FROM QUINTANA ROO, MEXICO AND ST. GEORGE ISLAND, FLORIDA**

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Nesting populations of loggerhead turtles (*Caretta caretta*) have been characterized by haplotype frequency distributions of approximately 400 base-pairs (bp) of the mitochondrial control region. However, due to extensive haplotype-sharing among populations, the accuracy of assignment tests and mixed stock analyses has been limited. In order to increase the genetic resolution of nesting populations, we used primers developed by Abreu *et al.* to amplify and sequence an extended fragment of the control region, approximately 800 bp, from loggerhead samples collected in Quintana Roo (QR) on the Caribbean coast of Mexico (n=100) and St. George Island (SGI) in northwestern Florida (n=22). Using the shorter control region sequence, 11 haplotypes were uncovered in the QR and SGI samples. The QR samples comprise 10 haplotypes, eight of which are unique to that population. A new haplotype not previously described or listed on the Archie Carr Center for Sea Turtle Research website (<http://accstr.ufl.edu/>) is among the three haplotypes detected in the SGI samples, and is not shared with QR. Increased polymorphism in the extended control region sequences (41 polymorphic sites) from samples in QR and SGI split the 11 short haplotypes (21 polymorphic sites) into a total of 16 long haplotypes. Of these long haplotypes, 14 are present in the QR samples and three in the SGI samples. Thus only one of the long haplotypes is shared between the regions. While common in QR, only 0.1% (2 out of 22) of SGI samples have this shared haplotype. Eight different nesting beaches were sampled along approximately 50 km of coastline in central QR. The distribution of long haplotypes among these beaches indicates a north-south division. While some haplotypes are shared (6), many are unique to the northern beaches (7) and one is

unique to the southern beaches. Of the two long haplotypes shared between QR and SGI, one is present in both the southern and northern beaches of QR, and the other is unique to the northern beaches. Increased diversity of the long haplotypes (0.84) compared to the short haplotypes (0.76) and the presence of unique alleles in SGI and in northern and southern beaches in central QR indicate the usefulness of the extended control region in characterization of nesting beach populations, which will lead to increased reliability of assignment and mixed stock analyses.

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## DETECTING GREEN TURTLE POPULATION STRUCTURE IN THE PACIFIC USING SINGLE NUCLEOTIDE POLYMORPHISMS (SNPS)

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We developed and applied a set of nuclear single nucleotide polymorphisms (SNPs) to detect genetic stock structure among Pacific *C. mydas* nesting populations. Sampled populations included Galapagos n=56, Mexico n=74, Hawaii n=136, and Taiwan n=12, to represent eastern, central, and western Pacific regions. A combination of single independent loci and linked loci combined as haplotypes were used for a total of 21 independent markers. Our nuclear markers confirmed significant differentiation between populations in the three Pacific regions. In addition, we discuss the value of SNP markers as an addition to the use of mitochondrial DNA and as an alternative to other nuclear DNA markers such as RFLP and microsatellites in *C. mydas* population studies.

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## GENETIC POPULATION STRUCTURE WITHIN THE FLORIDA GREEN TURTLE (*CHELONIA MYDAS*) ROOKERY\*

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Green turtle nesting has increased dramatically in Florida over the previous twenty years, making Florida an important source rookery for northern Caribbean foraging stocks. However, little has been published on the genetics of this rookery since the initial analysis of 24 samples collected from Hutchinson Island during the 1986 and 1990 nesting seasons. Given a critical assumption of mixed stock analyses that all potential source populations have been fully characterized in terms of their mitochondrial DNA haplotype frequencies, we determined that the genetic population structure within the Florida rookery warranted further study. During the 2007 nesting and hatching seasons, we collected 250 samples from 9 sites representing the major Atlantic coast nesting beaches as well as the southwest Gulf coast and the Marquesas Keys. We sequenced the mitochondrial control region and assigned haplotypes based on the HDCM-LDCM fragment in accordance with Archie Carr Center for Sea Turtle Research nomenclature. A total of eight haplotypes were found, with Cm-A1 and Cm-A3 accounting for approximately 95% of individuals surveyed. Cm-A8 and Cm-A5 were found in one individual each, invoking very low levels of recent connectivity with distant rookeries in

the southern Caribbean and South Atlantic. Cm-A13, previously described from Florida foraging sites and nesting beaches in the Mediterranean, was found in three nesting females. This suggests that the Cm-A13 juveniles may be locally derived rather than being trans-Atlantic migrants. Despite nearly complete sharing of the two common haplotypes among nesting beaches, haplotype frequencies exhibited strong structure. Cm-A1 is the common haplotype on the northern beaches, and Cm-A3 is present at high frequencies on the southern Atlantic coast beaches. A haplotype frequency transition zone in the vicinity of Jupiter Island is roughly concordant with a similar frequency break detected in loggerhead turtles. Complete delimitation of management unit boundaries will require further sampling; however, AMOVA results provide strong support for designation of at least two management units along the Atlantic coast. Small sample sizes and potential re-sampling prevented quantitative analysis of the southwest Florida and Marquesas Keys samples. Given the complete absence of Cm-A1 and relatively strong nest site fidelity of green turtles, these beaches may be demographically isolated from the Atlantic coast beaches. Additional sequencing of the mitochondrial genome is underway to search for additional informative variation. Samples collected during the 2008 nesting and hatching season will permit tests of intra-seasonal and inter-seasonal temporal variation as well as more robust inferences about management unit boundaries.

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## **CURRENT BIOGEOGRAPHY OF BLACK SEA TURTLE POPULATION (*CHELONIA MYDAS AGASSIZII*) IN THE EAST PACIFIC: TECTONIC AND PALEOMAGNETIC PERSPECTIVE**

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The breeding population of black turtle (*Chelonia mydas agassizii*) is restricted to the Eastern Pacific in the coast of the Mexican Pacific where it has areas of feeding and more important continental nesting sites and in the Galápagos Islands. Using the panbiogeographic model proposed by Croizat, which mentions that species and areas evolve together, and then through study of the distribution areas we can understand the current biogeography of the species. We carried out a Biogeographic analysis of the population of black turtle in the Eastern Pacific through the tectonic history of the nesting sites in the coast of Michoacán, Mexico and the Galápagos Islands. Using paleomagnetic features of their nesting sites of in Michoacán and Galápagos, we propose a Panbiogeographic model of the population of black turtles in the Eastern Pacific. This population apparently is an alopatric population that it could be isolated from the Atlantic populations of *Chelonia* from when the continental gap at Panama narrowed ca. 1.8 Million years ago. The geographic restriction of the reproductive adults of the black turtle to the coasts of the Eastern Pacific in the Galápagos Islands and the Mexican Pacific seems to be related to the geologic history of its nesting sites. The nesting sites of the black turtle population in Michoacán in the Mexican Pacific, according to paleomagnetic data, seems to be lands that formed as arcs of islands on the Cocos plate and they were adhered to the continent by tectonics of the plate before the formation of the American trench.

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## **SPECIES-SPECIFIC MICROSATELLITE ALLELES INDICATING INTROGRESSION IN SEA TURTLE SPECIES**

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The hawksbill turtle, *Eretmochelys imbricata*, is considered critically endangered by the IUCN, and in Brazil, mainly due to consumption of eggs and development of tourism along the coast, there are few nesting sites left. The loggerhead turtle, *Caretta caretta*, is considered endangered by the IUCN and by the Brazilian environmental agency

IBAMA. Hybridization between these two species has been reported for many decades from morphological studies. Recently, mitochondrial DNA (mtDNA) analysis was used to detect hybrids in Brazilian nesting beaches and feeding grounds, but the uniparental nature of this marker limits the outcome resolution and other autosomal markers must be applied to improve the results. In this study, we aimed towards the identification of specific alleles of parental populations (*E. imbricata* and *C. caretta*) through the analyses of 5 autosomal microsatellites loci markers. Autosomal markers were analysed in: 53 individuals from Bahia State in Brazil, identified as *E. imbricata* and bearing *C. caretta* mtDNA, 134 individuals identified as *E. imbricata* by morphology and mtDNA, and 71 individuals identified as *C. caretta* by morphology and mtDNA. For these 5 loci, 37 alleles were found for *E. imbricata* population (mean of 7.4 alleles per loci), with 18 *E. imbricata*-specific alleles (average of 3.6 alleles per loci). For the *C. caretta* population, 40 alleles (mean of 8 alleles per loci) with 21 *C. caretta*-specific alleles (mean of 4.2 alleles per loci) were encountered. The hybrid population presented 40 alleles (mean of 8 alleles per loci) with 13 *E. imbricata*-specific alleles, 12 *C. caretta*-specific alleles, 15 shared alleles and no hybrid-specific allele. The mean observed ( $H_o$ ) and expected ( $H_e$ ) heterozygosities were respectively 0.39 and 0.51 for the *C. caretta* (with one monomorphic locus and 2 loci fitting expectation for Hardy-Weinberg equilibrium (EHW)), 0.42 and 0.44 for *E. imbricata* (4 loci fitting EHW) and 0.89 and 0.7 for hybrids (only one locus fitting EHW). The hybrid group presented a high  $H_o$  value, clearly showing the hybrid nature of this population, which presents a great number of heterozygotes with *E. imbricata* and *C. caretta* alleles. No hybrid individual showed homozygosity for more than 2 loci, and at least 5 hybrid individuals may present introgression with *E. imbricata* and 2 with *C. caretta* for, at least, 1 locus. In long-term, this hybridization process with introgression can threaten the parental species identity and affect population fitness. If deleterious consequences of this process are confirmed, management strategies must be taken to reduce the impact of this event and guarantee the integrity of both threatened species. Acknowledgments: We thank Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), David and Lucille Packard Foundation, Sandler Family Foundation, and Marisla Foundation for the Travel Grants.

## **HEALTH, PHYSIOLOGY AND TOXICOLOGY**

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### **BACTERIA FLORA FROM THE OVIDUCTAL FLUID IN THE GREEN TURTLE, *CHELONIA MYDAS* WITH REFERENCE TO ANTIBIOTIC RESISTANCE**

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Sampling the oviductal fluid during oviposition was performed after the turtle had laid several eggs and had discharged oviductal fluid over its eggs at least three times to ensure that the lumina of the uterus, vagina, and the cloacae contain fresh oviductal fluid during the sampling collection. The samples were obtained by gently inserting a 15 cm sterile swab into the cloacal opening as the sphincter muscle is relaxed and the cloaca chamber is in a relaxed (envaginated) position, a common feature in turtles when they lay their eggs. The swab was long enough to reach the glandular lumina of the vagina where the oviductal fluid is accumulated. Thus this procedure is reliable in obtaining the freshly produced fluid directly from its origin. Otherwise it is difficult to reach the vagina in the non-egg laying turtles when the cloacal sphincter is closed and the cloaca is in a contracted (invaginated) position. A total of forty turtles were examined and all were contaminated with bacteria. The following microflora were isolated: *Citrobacter* spp. (53.5%), *Pasteurella* spp. (16.3%), *Pseudomonas* spp. (11.6%), *Salmonella* spp. (11.6%), *Proteus* spp. (4.7%), *Shigella* spp. (2.3%). Resistance of 43 bacterial isolates to 15 antibiotics was tested and their resistance patterns were recorded. Thirty six bacterial isolates showed resistance. The percentage ratio of isolates resistant to number of antibiotics are as follows: 11% : 1, 16.7% : 2, 38.9% : 3, 13.9% : 4, 5.6% : 9, 5.6% : 10, and 4, 5.6% : 11, and 2.8% : 12 antibiotics. Sampling the oviductal fluid for the microflora will be of value in evaluating the status condition of the turtle which reflects on the hatching success. The presence of antibiotic resistant bacteria in the oviductal fluid is an indicator of environmental pollution in the feeding and nesting areas of this endangered species.

## **PLASMA ESTRADIOL AND PROGESTERONE LEVELS DURING EMBRYONIC AND POST HATCHING PERIODS IN THE GREEN TURTLE (*CHELONIA MYDAS*)**

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Eggs were randomly collected from different nests immediately after oviposition at Ras Al-Hadd Reserve. The eggs were placed in three different incubators set at 30, 28.5 and 26 degrees celcius. Incubation at 26 degrees produced 100% males, at 30 degrees produced 100% females while at 28.5 degrees produced 85% females. In the oviparous reptiles the cortex is well developed in females while the medulla is degenerated. In males, the reverse condition occurs. Further evidence of sex differentiation is the presence of estradiol and progesterone plasma levels in which females were significantly higher than that of males. In females at 32 and 45 days of incubation, estradiol levels were stable without any significant changes but immediately after hatching, there was a significant rise ( $P<0.05$ ) in level. At 32 days, male estradiol levels were undetectable but at 45 and post hatching, there were significantly very low steroid levels compared to females ( $P<0.01$ ). Females at 32 and 45 days of incubation revealed that progesterone levels were steadily increased at 45 days of incubation ( $P<0.05$ ) and there was further increase in post hatching. At 32 days, males progesterone levels were undetectable but appeared at significantly lower levels at 45 days and post hatching compared to females ( $P<0.01$ ). The results of this investigation may be of value in assessing population structure in this endangered species.

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## **BLOOD LEVELS OF COPPER, LEAD AND MERCURY IN GREEN SEA TURTLES (*CHELONIA MYDAS*) PRESENT IN TWO CONGREGATION SITES IN NORTHERN CHILE**

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Caleta Constitución/Isla Santa María and the Poza Histórica del Terminal Pesquero de Antofagasta, have been identified as two important congregation areas for green sea turtles (*Chelonia mydas*) in the north of Chile (II region of Antofagasta), constituting foraging habitats for the specie. The combination of an accelerated urban development and an increase in mining and industrial activities in the area, have gradually incremented the toxic waste materials in the marine environment, especially heavy metals. This study documents blood levels of cooper, lead and mercury found on 12 specimens of green sea turtle, captured on the congregation areas mentioned above, sites with different habitat qualities. The sampling was performed with the use of special nets. There were considered for this study, only apparently healthy individuals. Weight (Kg) and somatometric data (mm) were registered and previously to the release, the turtles were identified with metallic tags. The investigation will allow us to know the sanitary condition of the animals and by evaluating blood concentrations, to learn about the acute impact generated by marine pollution in green sea turtle populations, congregating in the region. This way we will be able to detect possible contamination sources on each zone, permitting pertinent private institutions and public authorities to apply appropriate and timely measures, considering the conservation status of the specie and the urgency in establishing management plans to protect it.

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## IN-WATER AND IN-AIR HEARING SENSITIVITY OF THE JUVENILE GREEN SEA TURTLE (*CHELONIA MYDAS*)\*

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Despite increasing levels of anthropogenic noise throughout the oceans, we know very little about the hearing capabilities of sea turtles or how they might respond to potentially harmful sources of anthropogenic noise. Researchers have hypothesized that sea turtles hear poorly in air and that the morphology of the sea turtle ear and the fat surrounding the ear are specialized for underwater sound conduction. However, very little research has been conducted to determine sea turtle hearing sensitivities, particularly underwater, and no attempts have been made to compare their in-water and in-air hearing sensitivities. We measured the hearing thresholds of five juvenile green sea turtles (*Chelonia mydas*) both in water and in air by recording auditory evoked potentials (AEPs) produced by the central nervous system. This technique has historically been used as a non-invasive, quick method for determining hearing in non-communicative species. AEP techniques have been used to determine the hearing sensitivity of human babies, fish, bottlenose dolphins, manatees, sea lions, skates and sharks. We recorded responses to click and tonal stimuli from 50 – 3200 Hz using subdermal electrodes and presented stimuli with an underwater speaker (Clark Synthesis AC339), calibrated with a hydrophone (High Tech, Inc.). Before testing, we isolated turtles from noise and vibrations and lightly restrained them to prevent excessive movement. For underwater measurements, the turtles were placed completely submerged 10 cm (measured at the location of the ear) below the surface of the water. A Tucker-Davis Technologies Auditory Evoked Potential Workstation with SigGen and BioSig software generated click and tonal stimuli and recorded AEP responses. Juvenile green sea turtle AEP signals exhibited a frequency doubling signature similar to fish. Results showed juvenile green sea turtle hearing sensitivity between 50 and 1600 Hz in water and 50 and 800 Hz in air, and ranges of maximum sensitivity between 50 and 400 Hz in water and 300 and 400 Hz in air, suggesting a wider range of increased sensitivity in water. In both water and air, sensitivity decreased sharply after 400 Hz. These results present a conservative estimate of hearing sensitivity as some thresholds, particularly at lower frequencies, may have been masked by background noise. We found that juvenile green sea turtles have a narrow range of hearing sensitivity and are most sensitive to low frequencies. They hear well in water, particularly at frequencies below 1000 Hz. When our resulting audiograms are compared with the frequencies and source levels (dB) produced by many anthropogenic sources such as low-frequency sonar, oil and gas exploration and drilling, and vessel traffic, it is clear that green sea turtles are likely able to hear much of the low-frequency marine anthropogenic sound in the ocean. We would like to thank the U.S. National Marine Fisheries Service for supporting this research and the International Sea Turtle Symposium, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation for travel support.

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## **DEVELOPMENT OF A STRATEGY TO STUDY THE TOXICODYNAMICS OF POLLUTANTS IN BREEDING SEA TURTLES FROM THE FRENCH WEST INDIES**

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Sea turtles including the green turtle, *Chelonia mydas*, and the hawksbill turtle, *Eretmochelys imbricate*, are critically endangered species facing poaching, incidental catch in fishing nets, destruction of their habitats and marine pollution. There is a paucity of data dealing with toxicants such as metals and persistent organic pollutants (POPs) in sea turtles. We developed a strategy to ascertain levels, effects and transfer to offspring of several pollutants in sea turtles. Sampling of blood, subcutaneous tissue and eggs of 15 gravid sea turtles *C. mydas* and *E. imbricate* was carried out between July and September 2008 in Martinique (Diamant's beach) and Guadeloupe (Terre de Haut in Petite Terre ; Trois-Ilets's beach and Galets's beach in Marie-Galante). The samples were collected when some eggs are observed in the clutch laid by the spawning sea turtles. Blood was collected from the dorso-cervical sinus using 21G needle (S-Monovette, Sarstedt, Belgium) and subcutaneous tissue was sampled in the shoulder using a 5 mm biopsy punch (Kai Europe GmbH, Germany). Three eggs and some sand were collected watching out to not damage the clutch burrowed by the sea turtle. A clutch triangulation was carried out in order to get back three late embryos after the incubation period. Tissues were stored at -20°C on the day of the collection, transported frozen on dry ice to Belgium and stored in a -80°C freezer until analysis. Total blood and serum were successfully taken for metal, POP and biomarker investigations. T-mercury was analyzed by DMA milestones while PCBs, DDT and chlordecone were analyzed by gas chromatography. Samples of serum were analyzed for vitamins (A and E) by HPLC and for thyroid hormones (triiodothyronine T3 and thyroxine T4) by radioimmunoassay. Similar to this field study, a cell model using 3T3-L1 cell line was built up to test in vitro effects of PCBs and mercury exposure on accumulation and mobilization events of adipocyte cells as well as the relationship between in vitro exposure and in vivo data. Increasing concentrations of pollutants were added to the cell culture at different stage of the adipocyte differentiation. Lipolysis and lipogenesis products (fatty acids plus glycerol and triglyceride respectively) were then measured. Preliminary results showed a dose-response relationship between increased Aroclor 1234 and 1252 concentrations (0.5 ppb, 1 ppb and 1.5 ppb) and adipocyte mortality (Nucleocounter). The strategy we propose here will bring further insights on levels and potential impact of pollutants on female sea turtles and their offspring.

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## **BACTERIAL CONTAMINATION AND COLONIZATION WITH REFERENCE TO ANTIBIOTIC RESISTANCE IN THE EGG COMPONENT OF THE GREEN TURTLE (*CHELONIA MYDAS*) IN OMAN**

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During egg laying, 56 eggs were collected from 8 nests of the green turtle, *Chelonia mydas*, immediately post oviposition, at Ras Al-Hadd Reserve in Oman . They were examined for the presence of bacteria in eggshells and egg contents. Eighty two percent of the eggs had bacteria belonging to ten genera where *Pseudomonas* spp. being the most frequent (30.3%), followed by *Salmonella* (19.2%) and *Enterobacter* (14.3%). Bacteria were found in 41.2% of yolk, 40% of eggshell and 20.1% of albumen. A similar pattern of bacterial distribution in egg contents was revealed when the eggs were challenged with 10<sup>6</sup> /ml of *Salmonella typhimurium*. Examination of oviductal fluid during oviposition

showed high bacterial contamination. The bacterial isolates, challenged by fourteen antibiotics showed multiple-resistance. Resistance to ampicillin was the highest (77.6%) followed by minocycline (65.8%).

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## **DEVELOPMENT OF CORNEAL FIBROPAPILLOMATOSIS IN GREEN TURTLES (*CHELONIA MYDAS*) IN QUEENSLAND AUSTRALIA**

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Cutaneous and visceral fibropapillomatosis are well documented in marine turtles. First recorded in green sea turtles (*Chelonia mydas*) in the Florida Keys in 1938, Kaneohe Bay in Hawaii in 1958, Grand Cayman Islands in 1980 potentially post introduction from Mexico in 1977, and in Repulse Bay in the central coast of eastern Australia in 1989, this panzootic is now known to affect all species of marine turtle, except the leatherback turtle (*Dermochelys coriacea*), yet its effect and distribution within marine turtle populations are still being measured. Corneal fibropapillomas have been previously described in a small number of eyes (n=4) from turtles stranded in the Florida Keys as morphologically distinct from those that occurred on the conjunctiva, nictitating membranes and soft integument of the ocular orbit. This was proposed to either indicate normal progression in tumour maturation, or differences in ocular microenvironments provided for tumour/viral replication. Corneal fibropapillomatosis has also been recorded in Hawaii, but has not previously been seen in Australian sea turtles. Over a 14 day period in June 2008 at Shoalwater Bay (22°20'S, 150°12'E) Queensland Australia, 569 green sea turtles were examined for abnormalities and signs of ill-health. Three of these animals were found to have corneal fibropapilloma tumours of varying size; another had post-traumatic corneal lesions with leech infestation; and another had post-traumatic corneal lesions consistent with the former, without leech infestation. Tumour tissues were collected and processed routinely for histological examination, and slides were examined by a veterinary pathologist. Tumours were concluded to be the same as those previously described for other cutaneous fibropapillomas; morphologic variations seen in the Florida study were not noted. The importance of corneal fibropapillomatosis to marine turtles is the potential implication of permanent loss of vision and increased susceptibility to diseases of associated ocular structures. This previously unseen manifestation in Australian waters (i) suggests potential spatial and temporal distribution patterns for fibropapillomatosis mimicking the global distribution patterns seen in the conventional form of cutaneous fibropapillomatosis; and (ii) may offer evidence to the theory of increasing disease emergence in the marine environment. One potential aetiology for these tumours is corneal trauma followed by infiltration with *Ozobranchus margo* leeches leading to development of fibropapilloma tumours on the cornea. Whether this manifestation is a result of increased incidence of corneal trauma and/or fibropapillomatosis requires comprehensive further investigation.

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## **USING PLASMA BIOCHEMISTRY AND HAEMATOLOGICAL BLOOD REFERENCE RANGES AS A TOOL IN DIAGNOSING DISEASE FOR GREEN TURTLES (*CHELONIA MYDAS*) IN QUEENSLAND, AUSTRALIA\***

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Numerous studies have presented serum or plasma biochemistry and haematological reference ranges for sea turtles, but few workers have attempted to use reference ranges to assist ante-mortem disease diagnosis. This is because of limited availability of reference ranges based on large sample sizes, limited understanding of the normal physiology of sea turtles, potential for spatial, temporal and species variation in normal biochemical and haematological values, and

limited knowledge of diseases and epidemiology of these diseases in sea turtles. Over 19 days between June and August 2007 in Moreton Bay (27°20'S, 153°23'E) and Shoalwater Bay (22°20'S, 150°12'E) Queensland Australia, 295 green turtles were captured by standard rodeo technique, clinically assessed by a veterinarian and had blood collected from the cervical dorsal sinus. Blood samples were processed by standard techniques. Of the 295 study animals, 194 were classified as apparently clinically healthy and 25 as apparently clinically unhealthy. Data was insufficient to categorise 76 turtles. Turtles in good body condition, displaying no visual abnormalities, neurological deficits or excessive epibiotic load, and having no evidence or known history (based on tumour scars and/or previous capture data) of fibropapillomatosis were classified as being apparently clinically healthy. Turtles in poor body condition and/or exhibiting clinical abnormalities and/or excessive epibiotic load were classified as apparently clinically unhealthy. Reference ranges were estimated using data from the clinically healthy turtles. Blood values from the clinically unhealthy turtles were compared to these reference ranges. Animals that were clinically normal other than having evidence or known history of fibropapillomatosis were excluded from all analyses. This study showed that reference ranges derived for Queensland green sea turtles may be useful as a screening diagnostic tool for ante-mortem clinical pathology in individual sea turtles sampled in this area. Unhealthy animals had plasma biochemical (albumin, alkaline phosphatase [ALP], aspartate transaminase [AST], creatinine, globulin, glucose, lactic dehydrogenase [LDH] and sodium) and haematological (thrombocytes) measures outside those of the proposed reference ranges. These results suggested that, based on blood measures, 84% of this unhealthy population had cardiovascular-related pathology, 74% had hepatic pathology, 57% had renal pathology and 52% had gastrointestinal-related pathology. These findings are similar to those from an ongoing concurrent post mortem investigation being conducted in green sea turtle populations from these two study sites where gross and histopathological examinations suggest that cardiovascular, hepatic, renal and gastrointestinal pathology are not uncommon. The aetiologies of these disease processes have not been defined. The results of this study (i) suggest that plasma or serum biochemistry and haematology reference ranges may be useful as a tool in diagnosing sea turtle disease; (ii) emphasize the importance of establishing reference ranges for use in rehabilitation centres and disease investigations for better definition of the health of the individual/ sea turtle population; and (iii) suggest that screening to identify the body systems affected in green sea turtles could guide the selection of specific secondary tests for more accurate diagnosis of disease.

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## RESPONSE OF SEA TURTLE HATCHLINGS TO LIGHTS OF DIFFERENT COLOUR\*

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Sea turtle eyes are highly developed and are a key sense for these animals for a range of behaviours. For instance it has been shown in numerous studies that light stimuli are crucial to sea turtle hatchlings' ability to find the sea after emerging from their nests on the beach. In this study the innate light-orienting behaviour of hatchling sea turtles was utilised to learn more about the animals' ability to see lights of different wavelengths (colours). This study aimed specifically to establish visual thresholds for different wavelengths of light, revealing which wavelengths the animals are more sensitive to. Hatchlings of the loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) sea turtle were tested in a Y-maze behavioural arena shortly after emerging from the nest. The animals had to choose between a dark and a dimly lit stimuli presented at the end of each arm of the maze. At the completion of the experiments the hatchlings were released onto the beach. Results showed that hatchlings of all species tested here responded to wavelengths between 365nm (UV light) and 700nm (red). All species were more sensitive to the shorter wavelength (representing colours such as UV and blue) than the longer wavelength (yellow and red) and species-specific differences of visual thresholds for different wavelength were found. Australian loggerhead sea turtles did not show any avoidance behaviour to the colour yellow (600nm), unlike populations in Florida that were tested in a previous study. None of the hatchlings tested here showed orienting behaviour to infrared light (800nm). This research has implications for many of the man-made sources of lights that sea turtles encounter during their lifetime, such as beach lighting and luminous light sticks used in the longline fisheries.

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## COMPARATIVE HEALTH ASSESSMENT OF WESTERN PACIFIC LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) FORAGING OFF THE COAST OF CALIFORNIA, 2005-2007\*

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Leatherback turtles are critically endangered, with the most severe declines having occurred in the Pacific Ocean (IUCN, 2007). Major threats to the Pacific leatherbacks are predominately anthropogenic including loss of nesting habitat due to coastal development, over-harvesting of eggs, and incidental bycatch in gill-net and longline fisheries, as well as nest predation and beach erosion. Genetic and satellite telemetry studies have shown that leatherback turtles that forage off the coast of California are part of a genetically distinct Western Pacific breeding stock that migrate to nesting beaches on Papua, Indonesia to reproduce. While it has been proposed that the rapid decline of the Pacific population is due to increased mortality, little is known about the health of this species. To date, health assessment studies in leatherbacks have focused on sampling females on nesting beaches due to the relative ease of capturing and sampling these large sea turtles on land. Although these studies provide valuable biological information, sampling is biased by sex and physiologic state, so that the applicability of the data to the population as a whole is constrained. This study provides the most comprehensive assessment to date of the health status of leatherbacks in the Pacific. Adult leatherbacks (n=19, 6 males, 13 females) were captured by boat along the coast of central California from 2005 to 2007. Blood was collected from the dorsal cervical sinus and/or the popliteal vein and external physical examinations were performed to assess the health of each individual. Physiologic parameters such as temperature, respiratory rate, and heart rate were measured to determine baseline ranges for leatherbacks during capture. Hematology and plasma chemistry panels were performed and exposure to heavy metals (Pb, Hg, and Cd), organochlorine contaminants, and the marine biotoxin domoic acid was assessed. Blood parameters from Pacific foraging leatherbacks were compared with nesting female leatherbacks from the Western Pacific in Papua New Guinea (n=9), the Eastern Pacific in Costa Rica (n=8), and the Atlantic in St. Croix, US Virgin Islands (n=12). Results of this study will serve as baseline health information and provide a foundation for expansion of such health assessments to address the conservation and recovery of this endangered species. Acknowledgements: This research was funded by the Oiled Wildlife Care Network at the Wildlife Health Center, School of Veterinary Medicine, University of California, Davis; the Theodora Peigh Dual Degree DVM/MPVM scholarship; and the National Marine Fisheries Service, Southwest Fisheries Science Center's Marine Turtle Ecology and Assessment Program. We gratefully acknowledge travel support from International Sea Turtle Symposium, through generous donations by the Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, US National Marine Fisheries Service, US Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation.

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## THE EFFECT OF HEAVY METALS ON STEROID AND METABOLITE CONCENTRATIONS IN NESTING *NATATOR DEPRESSUS*

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Plasma levels of six steroid hormones (progesterone, testosterone, dihydrotestosterone, oestrone, thyroxine and corticosterone) and plasma metabolite (i.e. glucose and triglyceride) levels were analysed during the nesting season in

flatback turtles, *Natator depressus* in Queensland, Australia. Hormones and metabolites are regulated to maintain homeostasis and to enable successful nesting activities in female sea turtles such as *N. depressus*. Because they could potentially interfere with hormones and/or metabolites during the nesting season we monitored hormone, metabolite and heavy metal concentrations in the blood and egg tissues in *N. depressus*. In the blood, zinc was present at the highest concentration of  $152.53 \pm 1.45 \mu\text{g/L}$ , followed by copper ( $7.74 \pm 0.09 \mu\text{g/L}$ ) and lead ( $0.08 \pm 0.05 \mu\text{g/L}$ ). To assess hormonal and/or metabolite imbalances in nesting turtles due to the presence of heavy metals, relationships among steroids, glucose, triglyceride and heavy metal concentrations were measured. Zinc concentrations (previous measured in blood) were positively correlated with testosterone concentrations. However, concentrations of magnesium and chromium, measured in eggs, were negatively correlated with progesterone and corticosterone levels, respectively. Magnesium was also positively correlated with triglyceride concentrations in *N. depressus*. The biological significance, if any, of the correlations observed among heavy metals, hormones and metabolites is unknown. Further studies are needed to determine whether the presence of these heavy metals affects nesting activities in *N. depressus*. It is necessary to understand whether the aforementioned observed correlations among heavy metals, steroids and metabolites could assist or potentially disrupt nesting activities in *N. depressus*. Consequently, it is important to evaluate the range of heavy metal concentrations present in *N. depressus* tissues (i.e. blood and eggs) that could interfere (be beneficial or disrupting) for nesting success. This knowledge will assist in developing better management plans for the conservation of nesting *N. depressus*, an endemic Australian species.

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## **CONTAMINANT LEVELS, BIOACCUMULATION AND HEALTH EFFECTS IN *CHELONIA MYDAS* IN SAN DIEGO BAY, CA\***

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Many trace metals and persistent organic pollutants are known to exceed probable effects levels in the San Diego Bay where a population of East Pacific green turtles (*Chelonia mydas*) are known to forage and reside most of the year. In 2007-2008 non-invasive blood and scute sampling was used to measure these contaminants in 21 individuals in the San Diego Bay population. Food sources from nine sites in the Bay were also analyzed to investigate bioaccumulation and identify specific foraging areas. Finally, complete blood cell counts and blood chemical panels were conducted to investigate correlations of contaminant load and health. Significant levels of several non-essential metals persistent organic pollutants were found in multiple individuals, and patterns of contaminant loads varied by sex and size class. Principle Components Regression and MANOVA were used to assess relationships between toxin levels, health status, and bioaccumulation in the green turtle food web. Results from this study are being used to make recommendations for foraging habitat protection and tighter regulation of chemicals in the San Diego Bay watershed.

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## **BODY CONDITION FOR THE BLACK TURTLE, *CHELONIA MYDAS AGASSIZII*, IN BAJA CALIFORNIA SUR, MÉXICO**

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Body condition index has been used to describe the health of several species, their well being and is generally considered as a measure of the individual energy reserves. The survival, reproductive success and, thus, the population dynamic depend on body condition of the organisms. In this study an annual and seasonal body condition index (a) was estimated for the black turtle, *Chelonia mydas agassizii*, in two mangroves of Baja California Sur during 2005-2007 with a lineal model between the weight (kg) and length (cm) of the individuals. The b parameter was estimated from

the lineal regression (weight-length) and the isometric assumption was evaluated in the black turtle ( $b=3$ ). The relative body condition index suggested by Le Cren (1951) was made using the growth parameter ( $b$ ) estimated for the black turtle. The body condition index suggested by Bjorndal *et al.*, (2000) was calculated for comparisons. Seasonal, annual and study sites differences in the condition factor ( $a$ ) were evaluated with the analysis of comparison of two intercepts, comparisons between indexes were made and was related with blood biochemistry parameters of turtles analyzed. Differences in body condition between age and health status were assessed. Body condition of the black turtles varied between years and study sites ( $p<0.05$ ). There was an increase of the body condition from winter to summer in both zones, although it was not statistically significant ( $p>0.51$ ). The major body condition index observed during summer and the years 2005, 2006 coincided with major concentrations of glucose, proteins, lipids, calcium, uric acid and the lowest concentration of the enzymes that suggest kidney dysfunction ( $p<0.05$ ). The black turtle growth did not follow an isometric pattern ( $b=1.38$  kg/cm) ( $t$ -Student  $0.05(2), 120=16.23, p<0.000$ ). The body condition index was correlated with individual size (straight carapace length SCL) considering all age classes in both zones (BMA  $R^2=0.26$ , PAO  $R^2=0.97$   $p<0.001$ ). Body condition between healthy and injured sea turtles was not different when age groups were considered ( $p>0.12$ ), nevertheless injured sea turtles captured in Bahía Magdalena showed a lower average of body condition than healthy ones. Conservative results were obtained with the relative body condition index ( $U(0.05(2), 101, 101=2497, p<0.000$ ) as isometric growth was not assumed for black turtles; This is a favorable assumption when conclusions about the health status of populations under some kind of risk are made. The body condition estimated with both indexes coincided with the physical and clinical state observed in black turtles, so this method could be considered as a simple and immediate evaluation of individual health in black sea turtles.

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## **BLOOD BIOCHEMISTRY VALUES OF THE BLACK TURTLE, *CHELONIA MYDAS AGASSIZII*, IN THE OCCIDENTAL COAST OF BAJA CALIFORNIA**

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The black sea turtle, *Chelonia mydas agassizii*, is one of the five species of sea turtles found in Baja California Sur, where several bays and lagoon systems provide an important growth and feeding habitat mostly for juvenile black turtles. The health status of the black turtle population in Baja California Sur is currently unknown. Great variety of heavy metals and organochlorine compounds, histopathologic damage related to intoxication by unidentified pollutants and parasitism by trematodes have been reported in tissues of these turtles. In this work blood biochemistry values of black turtles captured alive in two mangroves of Baja California Sur during 2005-2007 are characterized and compared by abiotic (year, season, location) and biotic factors (age, physical state and body condition). Blood samples were collected from the dorsal cervical sinus, serum obtained by centrifugation were evaluated using commercial kits. Eighteen biochemical parameters, including proteins, lipids, electrolytes, glucose, calcium, inorganic phosphorus, excretion products and activities of five enzymes, were evaluated. Juveniles were the dominant size class in both zones, the size range was 43.9-92.4cm straight carapace length (SCL) in Punta Abreojos and 41.4-80.3cm SCL in Bahía Magdalena. Black turtles showed differences in the variability of the biochemical parameters between zones. There were no differences in biochemistry values between healthy and injured sea turtles in Bahía Magdalena, where juveniles had higher glucose levels ( $p=0.003$ ) and average calcium than subadults. In Punta Abreojos injured sea turtles had lower levels of calcium, potassium and inorganic phosphorus ( $p<0.03$ ) and higher concentration of colinesterase ( $p<0.001$ ) than healthy turtles. In this zone the adults presented higher levels of triglycerides ( $p=0.02$ ) and total proteins. In periods when the sea turtles had a better body condition (summer 2005 and 2006) individuals of both zones had higher concentration of lipids (cholesterol and triglycerides), glucose, uric acid and total proteins ( $p<0.04$ ), probably reflecting more food availability and energetic reserves, protein catabolism and a better nutritional status in such periods. Adults, subadults and individuals captured on years when the lowest body condition was registered showed higher ALT and AST rates ( $p<0.02$ ), which have been suggested as indicators of kidney dysfunction due to the toxic effects of PCB's in sea turtles. This is the first report of biochemical values and clinical state of black turtles in Mexico, new evaluations are necessary in order to assess physiological health and pathological changes, as well as to establish critical levels for the well being of the individuals.

## **CHANGES IN ULTRASTRUCTURE OF EGGSHELL DURING DIFFERENT PERIODS OF INCUBATION IN THE GREEN TURTLE, *CHELONIA MYDAS*, AT RAS AL-HADD**

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Eggs were randomly collected from green turtle nests at Ras Al-Hadd Reserve. The eggs were placed immediately in the incubator at 30 degrees C and the eggshell layers were examined, using scanning JSM-500L microscope. Three layers were recognized: at outer calcareous, middle multistrata and inner shell membrane. The calcareous layer had loose units in the form of nodules with numerous spicules arranged in folded stacks but gradually become unfolded during the incubation period. By the end of incubation, all the spicules were completely unfolded to form radiating configuration. The unfolded process of the spicules is probably caused by the expansion of the calcareous layer caused by moisture absorption during incubation, causing the spicules to separate from each other. No significant structural changes occurred in the middle layer and the inner shell membrane. Investigation on eggshell structure during incubation will be of value in assessing the hatching success in this endangered species.

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## **AUDITORY EVOKED POTENTIALS OF LOGGERHEAD (*CARETTA CARETTA*) AND GREEN TURTLE (*CHELONIA MYDAS*) HATCHLINGS AND POST-HATCHLINGS\***

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Auditory evoked potentials (AEPs) were measured in hatchlings and post-hatchlings (*Caretta caretta* and *Chelonia mydas*) to determine hearing ranges both in air and in water. Auditory evoked potentials are responses of the nervous system to an acoustic stimulus. The measurements of these responses are recorded by subdermal electrodes and multiple responses are averaged together. The final result is a sensitivity curve, showing the minimum detectable intensity for each frequency presented. Previous reports of hearing abilities in sea turtles are inferred from anatomical studies and from several studies measuring auditory evoked potentials in juvenile and subadult loggerhead turtles and in a single adult green turtle. The present study is the first to examine hearing in hatchlings and to compare both in-air and in-water hearing in hatchlings. This comparison is of particular importance as hatchlings transition from the beach to the aquatic environment. The subjects in this study were obtained from nests in Sarasota County, Florida, USA and were tested either within one day of arrival or after having attained post-hatchling status (greater than 50mm SCL). Hatchlings were tested with tones of known intensities, ranging from 50-6400Hz. Previous studies indicated the most sensitive thresholds were between 200-400Hz but limitations in equipment for these studies prevented testing of lower frequencies. This study was able to encompass the previously tested frequencies and extend the range to include higher and lower frequencies. Data collection and stimulus presentation were done with a Tucker-Davis Technologies (TDT) workstation using SigGen and BioSig software to control frequency and intensity. These data are of growing importance with the increasing presence of low-frequency anthropogenic noise in coastal environments. A better understanding of hearing in sea turtles may help better manage important habitats that are heavily impacted by human influence.

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## **HISTOLOGY ATLAS OF LOGGERHEAD SEA TURTLES, *CARETTA CARETTA***

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All marine turtles are threatened or endangered species, and thus the survival of every individual is important for species conservation. Several marine wildlife rescue centres work on sea turtle rehabilitation, but many times diagnosis is difficult due to the lack of reference data on healthy individuals. Therefore, knowledge based on healthy free-ranging individuals is needed for diagnostic and rehabilitation purposes. The objective of the present work is to present a histological atlas of loggerhead sea turtles for histopathological purposes. Turtles were obtained from incidental captures at Madeira-based black scabbard long-line fisheries. Freshly drowned turtles were necropsied immediately after retrieval from the fishing gear in order to collect tissues as fresh as possible. Tissue samples were fixed and preserved in 10% formaldehyde. The animals – 3 juvenile pelagic female loggerheads – were collected SE of Madeira Island, Portugal, NE Atlantic. Straight carapace lengths (SCLnt) were 404mm (Wt=20kg), 450mm (Wt=17kg) and 475mm (Wt=19kg). Samples were collected from the following organs: trachea, bronchus, bronchiole, lung, rhamphoteca, palate, proximal esophagus, distal esophagus, esophageic papillae, proximal stomach, distal stomach, duodenum, jejunum, colon, rectum, cloacae, thymus, spleen, pancreas, liver, gall bladder, salt gland, kidneys, bladder, ovaries, carapace, skin, bone (humeri), skull, skeletal muscle, smooth muscle, cardiac muscle, brain, cerebellum, pineal gland and olfactory nerve. Tissues were prepared using standard histological procedures. Both paraffin or methacrylate were used to embed samples. Histological colourations were Periodic Acid Schiff (PAS), haematoxylin-eosin (H&E) and Toluidin Blue. Muscular and digestive systems are already histologically described. Other organs systems are currently underway. This histology atlas will be a first contribution to a better understanding of health status, and a helpful tool for the recovery of sick and injured animals and subsequent release into the wild as well as for captive animals kept on display in public aquaria. The authors acknowledge the International Sea Turtle Symposium and the following organizations: Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund) and the Marisla Foundation for providing a traveling grant to attend the Symposium.

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## **DO PIT TAGS MIGRATE IN SEA TURTLE FLIPPERS?**

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Various tagging techniques are used to identify individual sea turtles during census, mark and recapture or other research studies. External tags are commonly used but may be shed or lost. More recently, Passive Integrated Transponder (PIT) tags have been adopted as a more permanent method of marking individuals, with a much lower rate of tag loss. PIT tags are small microchips with antennas encased in glass that are inserted under the skin or into muscle; they transmit a unique identification number when interrogated with a hand-held reader. Despite the lack of standardization in tag location, PIT tags are an integral part of many mark/recapture studies of juvenile and adult sea turtles worldwide. PIT tags are often inserted under the skin of the trailing side of a sea turtle's flipper blade or, in large species, in shoulder muscles. The predominant placement of PIT tags in cheloniids is along the flipper blade, however no studies of the possible negative effects and/or movement of the tag have been conducted despite stranding records of turtles with joint injury associated with PIT tag migration. In this study, we examined Magnetic Resonance Imaging (MRI scans) of loggerhead (n = 21) and Kemp's ridley (n = 24) juvenile turtles to examine the possible migration of PIT tags at two separate locations: (1) deep to the skin of the trailing (postaxial) side of the flipper and (2) within the

triceps muscle on the anterior arm. MRI scans taken just after tag insertions and again at 107 days after insertions were compared to identify which location allowed the least PIT tag movement. Tag movement (defined as >0.2 cm) was observed at both locations in loggerheads; movement was noted in 33% of tags (n = 7) when tags were placed deep to the skin of the trailing side of the flipper, and in 14% of tags (n = 3) when placed within the triceps muscle. In Kemp's ridley turtles, no tag movement was observed by tags placed within the triceps muscle, whereas movement was observed in 38% of tags (n = 9) placed deep to the skin in the trailing side of the flipper. Tag location consistency is an important aspect in mark/recapture studies, as it facilitates the ease and accuracy, of individual identification during recapture events. We compare the pros and cons of PIT tag placement in the two sites and make recommendations for standardized PIT tag placement that minimizes injury risk to sea turtles.

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## **PERFLUORINATED CONTAMINANT CONCENTRATIONS IN LOGGERHEAD SEA TURTLES: EXPANDED SPATIAL AND TEMPORAL TRENDS ALONG THE EAST COAST OF THE UNITED STATES\***

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Fluorinated organic compounds persist in the environment long after they have been used commercially, and perfluorinated compounds (PFCs) are found in a range of goods such as stain-repellents on cookware, leather, clothing, paper, and carpet. PFCs get released into the environment during the manufacturing, use, or disposal of these goods, and some of these compounds such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) can bioaccumulate into plasma and liver and biomagnify up food webs. Laboratory research indicates some PFCs are toxic to the liver and suppress mice immune systems at concentrations that are currently measured in some sea turtles. Our collaborative studies have observed that PFCs correlate with several health parameters in loggerhead sea turtles, indicating that their immune system and liver may be negatively affected by these compounds. Additionally, higher concentrations of PFCs have been recently found in loggerhead turtles captured in North Carolina than in northern Florida. This study attempts to expand that former work by looking at a larger spatial range of PFCs in loggerhead plasma along the East Coast of the United States as well as looking for temporal variation in PFC concentrations in order to locate hotspots of exposure and determine if concentrations are increasing through time. Loggerhead plasma samples were extracted by solid-phase extraction and quantified using liquid chromatography tandem mass spectroscopy for the mass fractions (concentrations) of 13 PFCs. For the spatial study, plasma was collected from turtles captured in 2005 and 2006 off of Cape Canaveral, FL, off of Charleston, SC, inside Core Sound, NC, and inside Chesapeake Bay, MD. PFOS and perfluorodecanoic acid (PFDA) concentrations were significantly higher in turtles from higher latitudes ( $p < 0.01$ ). In addition, temporal trends were measured in plasma from turtles captured off of Charleston, SC, from 2001-2007. Concentrations of PFOS and perfluorohexane sulfonate (PFHxS) significantly decreased during this time ( $p < 0.001$ ). This presentation will discuss possible reasons for these trends and their implications for sea turtle biology and conservation as well as provide additional results from on-going analyses of samples collected from near the Florida Keys and from 2008, which will expand both the spatial and temporal trends. This study helps to assess the environmental risks posed to loggerhead sea turtle populations by these contaminants along the East coast of the United States.

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## CARAPACIAL SCUTES OF HAWKSBILL TURTLES: UNLOCKING THE SECRETS WITHIN

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The ability to quantify status objectively, track changes in population size and structure over time, and manage wild hawksbill populations for conservation and/or sustainable use purposes, all require the development and application of appropriate survey methodologies, each of which has constraints and limitations, and is based on certain assumptions. The only real mechanism for achieving an integrated estimate of age-specific survival rates, across the full range of animals in the population, is to quantify the age structure of a population and measure the mean trend from cohort to cohort. The structure and colour of the keratin plates of hawksbill is affected by changes in growth rate, in both captive-raised and wild hawksbills, which suggests that the plates contain information on the relationship between size and age. The ability to use the colour pattern on the first costal plate as a morphological age indicator depends on the ability to relate growth increments in this plate to growth increments in body size. Using scutes derived from Cuba's traditional harvest as an example, we provide some interesting insights into how fast the average hawksbill may grow. A diversity of individual hawksbills, from fast and slow-growing juvenile raising sites, appears to contribute to the free-swimming population in Cuban waters, and be intercepted by the traditional harvest. Yet it is clear that the average individual in the 500 to 800 mm SCL size class are growing reasonably rapidly, which was not apparent from mark-recapture studies in shallow reefs (80 cm SCL).

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## A RETROSPECTIVE STUDY OF HISTOLOGICAL LESIONS IN STRANDED SEA TURTLES IN THE GOLD COAST REGION, QUEENSLAND\*

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There have been very limited numbers of surveys of wild sea turtles involving thorough documentation of diseases and causes of mortality. Significant numbers of veterinary facilities worldwide receive stranded turtles, however there is minimal information on reasons for stranding or the likelihood of successful rehabilitation of these animals. The aim of this retrospective study was to histologically examine tissue specimens taken during post-mortem examination of 29 sea turtles stranded on the South-Eastern coast of Queensland, Australia and submitted to Sea World on the Gold Coast, between 1997 and 2008. All of the turtles were presented for rehabilitation, but either died or were euthanased. There were 25 green turtles (*Chelonia mydas* 86.2%), 3 hawksbill turtles (*Eretmochelys imbricata* 10.3%), and 1 flatback turtle (*Natator depressus* 3.5%). Many of the turtles were subadults. Specimens were processed routinely for histological examination, and slides were examined by a veterinary pathologist and assessed for lesions considered to have contributed to stranding and/or death. No diagnosis was obtained in 10 cases; no brain tissue was submitted for 8 of those turtles. In the remaining 19 turtles, one or more significant disease processes were noted. The most common lesion (n=10) was extensive granulomatous meningoencephalitis centred on spirorchid fluke eggs, with small parasites noted within meningeal and parenchymal blood vessels. Severe fluke-associated lesions were noted in other organs in 7 turtles including lung, heart, kidney, intestine, liver and spleen; 5 of these turtles did not have significant neurospirorchidiidiasis. Coccidial enteritis (*Caryospora cheloniae*) was noted in 4 animals, with significant tubulonephritis in one turtle. In one animal perivascular coccidial aggregates were noted in the brain in addition to fluke-associated lesions. The results of this study indicated that severe meningoencephalitis associated with spirorchid fluke egg deposition was a significant cause of stranding in this series of cases, involving over half of the turtles for which brain tissue was submitted (10/19). In many cases the parasites were noted within both meningeal and

parenchymal vessels, in contrast with a previous report of stranded turtles in Florida where parasites were isolated from meningeal vessels only. This finding emphasizes the importance of (i) a thorough assessment of the neurological status of stranded turtles at presentation (ii) the need to obtain brain tissue at post-mortem examination (iii) the need for an ante-mortem test for significant spirorchid infection of the central nervous system. These results also indicated that *Caryospora cheloniae* was a continuing cause of mortality in sea turtles in this region, having been previously reported as a cause of epizootic mortality in 1991. As expected, more than one significant disease process was noted in some animals. Many of the sea turtles in this study had severe disease that was unlikely to respond to treatment, and would have justified euthanasia at submission if the diagnosis could have been made ante-mortem. This indicates the importance of documenting both gross and histological lesions in animals that die in rehabilitation centres, and of developing diagnostic tests to enable welfare-oriented treatment decisions to be made.

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## **MATERNAL INVESTMENTS: MERCURY AND SELENIUM IN HATCHLING LEATHERBACK SEA TURTLES (*DERMOCHELYS CORIACEA* V.) AND THEIR MOTHERS\***

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Pollutants from anthropogenic sources are among the threats marine turtles face. Mercury (Hg) is a chemical element that enters the ocean through industrial sources and natural geologic processes. It lacks biological function and can compromise health and impede normal development. Selenium (Se) is a trace element that acts to detoxify Hg in the liver. Hg and Se enter the body through food and water intake and are transferred from females to their offspring via the yolk. We measured Hg and Se in blood (pooled samples from 5 – 10 hatchlings/nest) collected shortly after emergence. Additionally, up to 5 dead-in-nest hatchlings were collected and their livers were tested for Hg and Se. These values were compared, by nest, to Hg and Se concentrations measured in blood collected from nesting females to determine if the values were correlated. The blood levels indicate the current status of these elements in the body while liver levels indicate long term status. Liver Hg concentrations in dead-in-nest hatchlings ranged from 0.075 – 0.25 ppb (n=18, mean=0.14 ± 0.06 ppb, wet weight basis) while liver Se concentrations ranged from 0.97 – 2.1 ppm (n=12, mean=1.43 ± 0.38 ppm, wet weight basis). Blood Se concentrations in hatchlings (1.4 – 6.97 ppm, n=22 nests, mean=4.07 ± 1.41 ppm) were significantly higher (p=0.002) than liver Se. This suggests that hatchlings have yet to detoxify any maternally derived Hg. An inverse relationship exists between each nesting turtle's blood Se and that of its offspring. Individual nesting leatherbacks can differ in how much Se they provide to their eggs. We hypothesize that nesting females detoxify more Hg with Se, and pass on less Hg and Se to their offspring. Our data suggest that hatchling liver Hg concentrations (Hg mobilized from their yolks) tended to be high when maternal blood Hg concentrations were high. We also analyzed liver Hg and Se in hatchlings that were brought into the lab for a separate study. Of these hatchlings, 6 died between 2 and 4 days of age (before feeding began). Hg concentrations in these turtles (mean=0.16 ppb, range=0.08-0.29 ppb) significantly increased (r=0.99, p=0.0003) with age, consistent with Hg mobilization from the yolk sac and suggesting that the detoxification process likely had not yet begun. We also found a significant positive correlation (r=0.49, p=0.05) between age of turtles and liver Hg concentrations (mean=0.95 ppb, range=0.1-3.32 ppb) once feeding commenced (≥6 days old, n=8 turtles). Liver Hg concentrations in these turtles were significantly greater (p=0.03) than in turtles that had not fed. This suggests that Hg accumulation is greater from food sources than from yolk mobilization. Our study is the first to establish these levels in hatchling leatherbacks, and to identify the roles of their mothers in transferring their Hg and Se loads.

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## **BLOOD CHEMISTRY VALUES ON LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*): FLUCTUATIONS IN COMPARISON OF CLINICAL CONDITIONS AND SAMPLE TECHNIQUES**

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Blood samples in *Caretta caretta* have been rarely explored and it's quite unusual to investigate and determine serum biochemical values correlating with the health of these animals. Nevertheless knowing blood parameters could be instrumental in rescue activities. We tried to discover possible existing relationships between clinical conditions and blood values. We have compared health conditions and investigated the physical diseases in a group of 80 *Caretta caretta*, recovered in the WWF Rescue Center of Lampedusa, between June and September 2008. We clinically monitored all the patients (5 males, 3 females and 72 subadults), and we drew blood samples by jugular and sometimes by occipital sinus. Blood sampling and serum handling were performed in two ways, in the light and in the dark. We determined the following serum parameters: total proteins, glucose, BUN, creatinine, uric acid, AST, ALT, CPK, ALP, amylase, cholesterol, triglycerids, total bilirubin, sodium, potassium, calcium. 48 sea turtles were in good condition, whereas 32 showed lesions caused by fishery interactions: flippers ischemic necrosis, hooks or lines into the digestive channel, and they all underwent an operation. The analytic results (mean±SD) were statistically analysed through ANOVA multivariation and Pearson test. We noted sample techniques influence in a significant statistic way ( $p<0.01$ ) the bilirubin results: this pigment resulted impossible to dose in samples performed in the light, but it was of  $0.15\pm 0.06$  mg/dl in dark samples, probably correlated to the high bilirubin photosensibility. We also registered significant statistic differences ( $p<0.01$ ) in glucose and cholesterol, linked to the weight: in over 20 kg turtles, these two parameters were proportionately higher in comparison with lower weight turtles. The comparison between healthy and sick turtles shows significant statistic differences for glucose ( $p<0.05$ ) and uric acid ( $p<0.05$ ), both higher in turtles needing an operation. The AST, ALT, CPK differences were lower between the two groups of turtles, anyway they were higher in physically stressed turtles, especially in the group of lower weight turtles. These last parameters could be considered indicative of poor muscular trophism; their evaluation could be very useful for prognosis. The significance of our results confirms the importance of the analytical determinations in order to better understand turtle conditions and to improve medical practices.

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## **EFFECTS OF REPEATED TISSUE SAMPLING ON THE GROWTH OF IMMATURE LOGGERHEAD TURTLES; A CONTROLLED STUDY**

**Kimberly J. Reich, Karen A. Bjorndal, and Alan B. Bolten**

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The increasing reliance on minimally invasive and non-destructive tissue sampling in animal isotopic ecology requires that we recognize and understand the effect of repeated sampling on the growth of immature animals. Our interest in using stable isotope analysis as a tool to investigate diet and habitat selection of young sea turtles was the basis for a long-term feeding study. Over the course of 120 days, we conducted repeated minimally invasive tissue sampling of skin, scute, and whole blood on rapidly growing loggerhead turtles (*Caretta caretta*). Each turtle was measured (SCL) and weighed every 10 days for the duration of the study. These results allowed us to evaluate the effect of this sampling regime on the growth rates of loggerheads. Loggerhead hatchlings were collected as they emerged from 6 nests in hatcheries in Broward County, Florida, and transported to the animal vivaria at the Department of Zoology, University of Florida (Gainesville, FL, USA) in June 2002. Samples of blood, skin, and scute were collected from a subset of turtles at eight intervals during the trial, which ran for 120 days. For sampling purposes, the hatchlings were divided

into 9 groups of 12 hatchlings. Each group contained 2 hatchlings from each of the 6 clutches. Sample collection was rotated among groups so that each type of sample was collected three times from each turtle over the 120 day period. Samples were collected as follows: 0.02 ml of blood was collected from the dorsal cervical sinus, a 2mm biopsy punch was used to collect 2 skin samples from the dorsal surface of the neck region, and a scute sample ~6mm<sup>2</sup>, was collected from the newly grown, anterior edge of the second caudal scute. All tools were disinfected prior to use, used on only one turtle, and discarded. During the trial, we also maintained hatchlings (controls, n=8) under identical conditions, without collecting any tissue samples. Growth trajectories for sampled turtles overlapped completely with control turtles, demonstrating no effect of sampling on growth rates. Upon completion of the sampling protocol post hatchling loggerheads were released as per the F.W.C. Marine Turtle Protection Program Guidelines. The release of all turtles was coordinated with the Marine Turtle Protection Program.

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## **DIAGNOSIS OF HEMORRAHAGIC ENTERITIS AND HEPATITIS IN A SUBADULT LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*) STRANDING IN ISLA ZAPARA, VENEZUELA**

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A subadult Loggerhead sea turtle was found stranded but still alive at North coast of Isla Zapara, Gulf of Venezuela (GV). The animal showed an important cover of epibiotic flora and fauna on its carapace. The first clinical evaluation suggested a debilitated corporal condition, loss of weight, dehydration, weakness, diminished muscular tonicity, paralysis of the limbs and lethargy. Members of the GTTM-GV rescued the turtle and started their rehabilitation, maintaining it in a swimming pool with little water and covered with humid towels. The first hematology revealed stress leukogram, then a treatment with a solution mixture to ringer lactate and dextrose 5%, vitamins of the complex B, and folic acid was used each 72 hours intravenously. Additionally, a treatment with enrofloxacin 5% was used each 48 hours on the limb muscle, both treatments during five days. Also daily sun baths and cleanings were applied. Despite the support treatment no improvement was observed, moreover, diarrhea with greenish yellow pigmentation of the urates, anorexia, regurgitation and prolapse of a portion of the cloaca. X-rays revealed sand along the transverse colon, without obstructive pattern. After three applications of enemas with physiological solution and glycerin this affliction was solved, and we restarted the force feeding by gastric sounding. A second hematology, after the support treatment and care offered, showed a normal leukogram. However, no improvement were observed, and the animal died after three weeks of rehabilitation. The histopathology post-mortem examination and analyses showed severe multifocal hemorrhagic enteritis ulcerous, with necrotic hepatitis. Similar diagnosis was observed also in another subadult loggerhead sea turtle, which stranded dead on the same island. Therefore, more research regarding potential causes of this sea turtles affliction in the study area is necessary.

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## **VITELLOGENIN PROFILE OF A MULTIPLE CLUTCH SEA TURTLE, *CARETTA CARETTA*, THROUGHOUT THE NESTING SEASON**

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Utilizing an enzyme-linked immunosorbent assay (ELISA), vitellogenin will be measured in plasma collected from nesting loggerhead sea turtles (*Caretta caretta*). Vitellogenin is an estrogen-induced phospholipoprotein that constitutes

the main egg-yolk protein in oviparous vertebrates. Of the sea turtle species, vitellogenin has been measured in *Chelonia mydas*, *Chelonia mydas agassizii*, *Lepidochelys olivacea*, *Lepidochelys kempii*, *Caretta caretta*, and *Dermochelys coriacea*; however, a vitellogenin profile has never been produced through direct methods for a nesting population in any species. Measuring vitellogenin concentrations in sea turtle plasma will allow us to gain an improved understanding of population dynamics with regard to reproductively active individuals. Our hypothesis is that multiple-clutch sea turtles like loggerheads undergo a second vitellogenesis some time during the nesting season given that abdominal space for the ovary is limited. A single female is capable of producing more than 100 eggs per clutch with an average of five clutches per season. One way to solve the problem of physical limitation for such an enlarged ovary would be to develop the ovary in two phases, the second one after the first clutches have been oviposited. This has yet to be reported for this or any other multiple-clutch sea turtle species. This is important because it is possible that females may be susceptible to disruption of reproductive function by environmental factors (e.g., limited food supply at nesting grounds) or anthropogenic activities (e.g., tourism or fishing industries) during the interesting interval when animals are close to the coastline. From June to August of 2008, 245 blood samples were collected from *C. caretta* nesting on Hutchinson Island, FL USA. Turtles were restrained after oviposition and approximately 8mL of blood from the cervical sinus was collected using a heparinized vacutainer. Samples were kept on ice until the end of the evening patrol (<6 hrs) when they were centrifuged and supplemented with aprotinin prior to transferring the plasma to cryovials for storage. Samples were kept at -4°C until they could be transported on dry ice back to the lab where they were stored at -80°C. Analysis is currently in progress and is expected to be completed in the coming months. It is expected that the analysis of these blood samples will help us to elucidate the dynamic nature of the sea turtle ovary.

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## A GREAT AUSSIE DIVER: THE FLATBACK TURTLE\*

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Flatback turtles, *Natator depressus*, have been reported to survive forced submersion better than other sea turtles, prompting questions about whether this species is particularly well adapted for long dives. Dive profiles were recorded in turtles from two breeding populations, Curtis Island in Queensland and Bare Sand Island in the Northern Territory, using Time-Depth Recorders (TDRs). Dives spent on the seabed were most prevalent, accounting for 57% of the time at depth. While on the sea bed, the turtles apparently remained inactive, cyclical changes in depth reflecting the tidal cycle. These inactive dives were long compared to those typical of other large sea turtles such as *Chelonia mydas* and *Caretta caretta*, up to 98 min (mean 80±12 min), and with a mean and median of 50 and 52 min, respectively. In addition, measurements of blood respiratory parameters were made on *N. depressus* at Curtis Island and, for comparison, on *C. caretta* nesting at Mon Repos, Queensland. Oxygen carrying capacities of 4.9 - 8.7 mmol liter<sup>-1</sup> (n = 49) in *N. depressus* are at the high end of the range in diving reptiles. Their mean oxygen affinity, P50, at 43 mmHg ± 5.3 SD, 25°C, pH 7.17, (range 37 - 55 mmHg) is slightly higher than in *C. caretta* (mean 46 mmHg ± 2.0 SD; range 43 - 49 mmHg) at comparable pH and temperature. The oxygen equilibrium curves, however, differed in sigmoidicity between the two species, with Hill n coefficients of 2.8 in *N. depressus*, compared with 1.9 in *C. caretta*. Inactive dives to the seabed was also recorded for the population of *C. caretta*, with maximum durations approximately half that of dives with similar profile in *N. depressus*. *N. depressus* are rarely found in waters deeper than 45 m. Their respiratory physiology may be suited particularly well to sustaining prolonged dives in shallow habitats.

## **HEALTH ASSESSMENT OF NESTING LOGGERHEAD TURTLES (*CARETTA CARETTA*) IN WESTERN AUSTRALIA\***

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Good health is critical for nesting sea turtles to sustain the migrations to the nesting sites and to guarantee successful reproduction. Due to the inherent difficulties in studying wild sea turtle populations, information on sea turtle diseases is fragmented. The purpose of this study was to collect critical baseline data of several blood health parameters and establish a health database on two important loggerhead turtle nesting populations in Western Australia, Dirk Hartog Island (Shark Bay) and Bungelup beach in Cape Range National Park (Ningaloo region). Established reference ranges for haematology, blood biochemistry and plasma concentrations of vitamin A, E and D of more than 150 nesting loggerhead turtles will be compared to ranges reported in literature. An important finding of the health assessment was the identification of an intraerythrocytic protozoal parasite during light microscopy examination of the thin-film blood smears. No protozoan haemoparasites have ever been identified in sea turtles. The identified parasite is morphologically similar to a malaria parasite, such as *Haemoproteus* or *Plasmodium* spp. These parasites are vector borne and are generally transmitted by biting flies of the order Diptera. The results of the diagnostic molecular study and population screening will be presented in combination with an assessment of the general health parameters of the affected turtles. Health assessments in conjunction with ecological data are crucial to obtain important baseline data and to understand and monitor the effects of anthropogenic changes on sea turtles. Acknowledgements: I gratefully acknowledge financial support for this project from the Department of Environment and Conservation, Murdoch University, BHP Billiton and the Hermon Slade Foundation, as well as travel support from the International Sea Turtle Symposium and all donors.

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## **ESTABLISHING A PRE-RELEASE PROGRAM FOR THE GREEN SEA TURTLE (*CHELONIA MYDAS*) AT THE CAYMAN TURTLE FARM LTD., 1968: TRANSITIONING HATCHLINGS TO THE WILD**

**Miriam C. Vadillo, Philip Admire, Bryan Andryszak, Marcus Williams, Ana Pinto, Chris Moersch, Ethan Manderson, and Erik Ebanks**

Cayman Turtle Farm Ltd., 1968

Since its inception, the Cayman Turtle Farm has released more than 31,000 farm-cultured juvenile green sea turtles to the sea. Beginning in July, 2007, a 'pre-release program' was developed at Boatswain's Beach/Cayman Turtle Farm to improve sea turtle adaptation to the wild, and learn more about the behaviour of juveniles under more natural conditions afforded by the 1.3 million gallon Boatswain's Lagoon (BL) exhibit. Here, young sea turtles swim freely with more than 3,000 fish. To date, two experimental groups of turtles have been studied. The first group consisted of 7 turtles, introduced at age 18 months, which were fed a diet of turtle pellets and maintained in BL for a period of 10 months, after which they were released. The second group, currently in BL, consists of 6 turtles, introduced at age 6 months, and fed cut fish. Visual and audible signals were successfully used to attract all turtles from both groups to one common feeding location. Each turtle was uniquely identified and notes kept on feeding and observed behaviors. All turtles were observed to begin eating algae that grows in the BL exhibit within about 4 months, relating this transition in diet to that of wild green sea turtles. Younger turtles (6 months) learn as quickly, are easier to manage, and present less of a predatory threat to exhibit fish than do older turtles. Preliminary findings strongly suggest the 'pre-release

program' as a superior method for transitioning farm-hatched turtles for release to the wild. The 'pre-release program' is also contributing to a better understanding of young sea turtle behavior as well as increasing public interest in conservation by affording interactive opportunities with Park guests. Future studies may include comparative growth and nutrition of wild, farm-cultured, and 'pre-release' turtles, and genetic research directed toward finding ways to optimize survivorship in the wild.

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## **PERSISTENT ORGANIC POLLUTANTS IN *CHELONIA MYDAS* EGGS: EVIDENCE OF MATERNAL TRANSFER, NESTING POPULATION VARIATION AND EFFECTS ON HATCHLING DEVELOPMENT\***

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Persistent organic pollutants (POPs) have adverse effects on the development and functioning of wildlife and have been reported in a limited number of sea turtle studies. However, the accumulation of POPs in sea turtles is not well understood. *Chelonia mydas* forage in shallow coastal areas and may accumulate POPs during feeding. Turtles from different foraging areas would therefore have different POP contamination profiles. Nesting female *C. mydas* may also transfer POPs to eggs and hatchlings due to the lipophilic nature of these chemicals and the mobilisation of lipids during vitellogenesis. This has the potential to disrupt hatchling development and compromise the viability of sea turtle nesting populations. The aims of this study were therefore to investigate: 1) the transfer of POPs from nesting female *C. mydas* to eggs and hatchlings; 2) the variation in POP contamination within a *C. mydas* nesting population; and 3) the effects of POPs on *C. mydas* hatchling development. At the Ma'Daerah Sea Turtle Sanctuary, Terengganu, Malaysia, blood and egg samples were taken from 11 nesting female *C. mydas* at the time of oviposition. The remaining eggs were transferred to a hatchery for incubation, and blood was subsequently taken from the emergent hatchlings. All blood and egg samples were analysed for 125 POP compounds using gas chromatography with coupled mass spectrometry. Emergence success, hatchling abnormalities and hatchling mass:length ratios were also recorded and correlated with the mean total POP concentrations for each nest. For all POP compounds detected, there were significant positive regressions between maternal blood and eggs ( $P < 0.05$ ,  $R^2 > 0.71$ ) and between eggs and hatchling blood ( $P < 0.05$ ,  $R^2 > 0.83$ ). This indicated that POPs were being transferred from nesting females to eggs during vitellogenesis, and further, from eggs to hatchlings during incubation. There was also significant separation in the chemical profiles between clutches (ANOSIM:  $P = 0.001$ ,  $R^2 = 0.99$ ), with six distinct groups on the non-metric multi dimensional scaling (nMDS) plot. As turtles from the same foraging areas would be exposed to similar chemical contamination, the separation on the nMDS plot may have represented six different foraging areas for these 11 nesting females. However, the variation in chemical profiles within a foraging area needs to be further investigated before this can be validated. Finally, as egg POP concentrations increased, hatchling mass:length ratios decreased (Regression:  $P < 0.05$ ,  $R^2 = 0.65$ ). This indicated that POPs could be affecting the development of *C. mydas* hatchlings in a way that compromises offshore dispersal and/or predator avoidance. This study therefore provides strong evidence of the maternal transfer of POPs to eggs and hatchlings, variations in chemical profiles due to different levels of exposure during foraging and adverse effects of POPs on the development of *C. mydas* hatchlings.

## **KEYNOTE ADDRESSES**

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### **GREEN TURTLES IN THE WESTERN ATLANTIC AND CARIBBEAN: WHERE HAVE WE BEEN AND WHERE SHOULD WE GO?\***

**Karen A. Bjorndal**

Archie Carr Center for Sea Turtle Research and Department of Zoology

The year 2009 – the centennial of the birth of Archie Carr on 16 June 1909 – is a very appropriate time to take stock of the green turtles in the western Atlantic and Caribbean. I appreciate the invitation from Colin Limpus to deliver a keynote address on this topic. Archie Carr studied all species of sea turtles in many areas of the world, and his work – both research and conservation – had global ramifications. But the heart of his studies was always with the Caribbean green turtle. In 1954, 55 years ago, Archie Carr wrote perhaps his most lyric and persuasive work on the imperiled status of sea turtles *The Passing of the Fleet*. This essay was first read as an evening lecture at the annual meetings of the American Institute of Biological Sciences and later published as a chapter in his book *The Windward Road*. It was a call to arms; many people throughout the world responded. Colin asked me to build around the theme “A review of 40 years of international marine turtle conservation action: what has worked and what hasn’t.” This is a difficult task. Even a cursory review of the actions, people, and institutions involved in the conservation of green turtles in the western Atlantic would require far more than the 20 minutes allotted to my presentation. Suffice it to say, if it takes a village to raise a child, it takes an ocean basin to conserve sea turtles. An even greater difficulty lies in evaluating “what has worked and what hasn’t.” I think the honest answer would have to be “we don’t know.” Long term data sets have revealed that two green turtle nesting populations in the western Atlantic – Tortuguero, Costa Rica, and Florida, USA – are increasing in abundance (Chaloupka *et al.* 2008). And populations from other nesting beaches, although the data are based on shorter timespans, also exhibit encouraging upward trends. Our joy at these apparent successes must, of course, be tempered with continuing concern over other populations that are not faring as well and with regret over the populations that have been lost. Since Archie wrote *The Passing of the Fleet*, a vast array of conservation initiatives, employing many management options, has been undertaken for the conservation of sea turtles. Some of the actions were major and of clear importance, such as the Costa Rican government establishing the Tortuguero National Park, with the resulting protection for the green turtles nesting there. But protecting sea turtles on the nesting beach alone is not sufficient to ensure their survival. The many, often small, actions of people throughout the region have accomplished a vast amount and have been equally important for the conservation of sea turtles. The educators, coastal villagers, biologists, fishers, sociologists, government officials, park wardens, beach walkers, and ship captains working together have brought us to where we are today. However, a fitting celebration of Archie’s centennial is not a review of the past, but a look to the future, not a tracing of where we have been, but an exploration of where we should go. So the main part of my talk will present the major challenges ahead of us and the major questions we must answer to conserve sea turtles for the future and for Archie’s bicentennial celebration.

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### **CONSERVATION OF LEATHERBACKS ACROSS A CHANGING PLANET\***

**Peter Dutton**

National Marine Fisheries Service, Southwest Fisheries Science Center.

This talk will highlight the unique biology and life history of the largest living marine reptile that faces imminent extinction in some parts of the Pacific. It will explore some of the scientific insights gained through modern research tools, and some of the mysteries that remain about this elusive creature that has inhabited our planet for over 70 million years. Having survived the last Ice Age, modern leatherbacks face new challenges from a changing planet and growing human population. Find out how these ocean migrants are uniting governments and local village communities together around the world to conserve this species, and the role Australia can play. This talk will examine the conservation successes and failures, and look to future challenges facing this endangered species.

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## **REDUCING SEA TURTLE MORTALITY FROM COASTAL FISHERIES: LESSONS FROM SOUTH CAROLINA\***

**Sally R. Hopkins-Murphy**

In 1979, the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) appointed a Marine Turtle Recovery Team. The team wanted to know how many turtles were dying each year and who had these data. Scientists were gathering data on stranded dead turtles in the southeastern U.S. but coverage was incomplete and there was no standardized data form. One of the first recommendations of the team was to establish a region-wide Sea Turtle Stranding and Salvage Network (STSSN), coordinated by NMFS, with a standardized form. The two most important factors, when quantifying mortality from a coastal fishery, are the temporal and spatial distributions of both the carcasses and of the fishing effort. Lesson 1: It is more important to have consistent, reliable data from most of your beaches than to have inconsistent, unreliable data from all of your beaches. In 1980, the spring large-mesh gill net fishery for Atlantic sturgeon was the first fishery that came to the attention of South Carolina sea turtle biologists. During April from 1980 to 1982, 96 sea turtle carcasses stranded in South Carolina and nearly all of them were in the area of the sturgeon fishery. The South Carolina Department of Natural Resources (DNR) shortened the sturgeon season in late April by two weeks in 1983, based on these data. This reduction of the fishing effort resulted in a decrease of sea turtle strandings during April 1983 to 1985, with 37 stranded sea turtle carcasses recorded. DNR closed the fishery in 1986 because of declining sturgeon stock. After this closure, there were only four sea turtle carcasses recorded during April from 1986 to 1988. Lesson 2: There is no “technical fix” (i.e., gear modification) to prevent sea turtles from drowning in gill nets. Eliminate the nets. The greatest source of mortality to sea turtles in southeastern U.S. waters was the incidental drown-ing in shrimp trawls. Mitigation with Turtle Excluder Devices or TEDs was necessary. The NMFS TED design was a three-dimensional box with slanted bars and a hinged door on top, installed just ahead of the bag of the net. It weighed approximately 100 pounds and fishermen considered it dan-gerous when swinging over the deck. In 1985, NMFS developed a lighter TED that would collapse on deck, but fishermen were very reluctant to use it. At the 6th Sea Turtle Workshop in Waverly Geor-gia (now the ISTS), a local shrimper displayed his TED, the Georgia Jumper, a two-dimensional oval grid installed just ahead of the bag at a 45-degree angle with an escape opening in the net. Local shrimpers had used these for years to remove cannonball jellyfish from their nets. Ultimately this type of TED design would be accepted. Lesson 3: Involve fishermen at the beginning of the process; they are more likely to know what will work and if the gear modification will be accepted by their industry. The 1980’s and early 1990’s were turbulent times for shrimpers, conservationists, government agencies and sea turtle biologists in the effort to implement TED regulations. The Center for Marine Conservation published a booklet in 1995 entitled “Delay and Denial: A Political History of Sea Tur-tles and Shrimp Fishing”, that documented important events and milestones during this time. Many fishermen insisted that they were not the cause of all the strandings and did not accept estimates from NMFS of 11,000 loggerheads and Kemp’s ridleys dying annually. In 1983, NMFS decided on a voluntary-use program instead of regulations. Shrimpers and environmentalists worked out an agreement to phase in TEDs in some areas at some times, but Louisiana shrimpers refused to sign it. NMFS published final regulations requiring TEDs beginning in 1988, but U.S. Coast Guard enforcement found widespread violations. On May 1, 1989, the new start date, Secretary of Commerce suspended enforcement for 60 days to give shrimper more time to install TEDs. When Gulf of Mexico shrimpers unlawfully blockaded the Houston shipping channel, he suspended it yet again and conservation groups sued. NMFS spent \$4.5 million tax payers’ dollars and many years developing a TED that no fisherman would use, while thousands of sea turtles continued to die. In South Carolina, aerial beach surveys from 1980 to 1987 showed that the loggerhead nesting population was declining 5% per year. In 1988, the DNR adopted TED regulations for all South Carolina state waters since the federal government had failed to make progress and fisherman-designed TEDs were available. Lesson 4: Compromise is usually not in the best interest of the resource. One Congressional mandate, lobbied for by the shrimping industry, required an independent review by the National Resource Council (NRC) on the causes and significance of turtle mortality, including that caused by commercial trawling. The number of strandings in South Carolina from 1980 to 1986 was five times higher (n = 190) during the two-week period just after the opening of the shrimp fishery when compared with the number of strandings during the two-week period immediately before the opening (n = 38). This held true even when the opening date varied from year to year. The NRC committee’s conclusion stated: “for juveniles, subadults, and breeders in the coastal waters, the most important human-associated source of mortality is incidental capture in shrimp trawls, which accounts for more deaths than all other human activities combined.” The NRC also noted in South Carolina that strandings declined in fall, even as shrimping effort was increasing, indicating the turtles had been “fished out”, not migrated, as we thought. In 1990, TEDs were required from May through August only. When September came shrimpers in South Carolina removed their TEDs and strandings for the fall months rose to the highest number since 1980. Turtles that survived during the

summer, died that fall. In 1991, TEDs were finally required year round in southeast U.S. waters. Lesson 5: Sometimes it is valuable to have “new eyes” examine your data; a wide range of reviewers is beneficial. South Carolina data also showed that TEDs reduced strandings by approximately 44% from 1990 to 1993. However, in 1995, strandings began to increase and were even higher in 1996, averaging nearly 150 per year from 1995 to 2001 compared to 100 per year during the previous seven years. Significant proportions of the strandings were adult-size loggerheads. What was the problem? In the mid 1980’s when the fishermen’s TEDs were being certified by NMFS there were no criteria for the design of the opening. They were tested simply by towing one net with a TED and the other net without a TED. If the TED net excluded 97% of the turtles, it was certified. NMFS amended the regulations to require a size for the TED opening beginning in 1993. The opening was triangle-shaped, 35 inches wide and 12 inches high. Surprisingly, the new opening was much smaller than the openings originally certified. NMFS reported between 33% and 47% of stranded loggerheads would not fit through the new openings (based on body depth). In the 1990’s, leatherback turtles that migrate through South Carolina nearshore waters during spring, were stranding on our beaches. Therefore, NMFS required shrimp trawlers to install TEDs with openings large enough to exclude leatherbacks, but only on an emergency basis and only when leatherbacks were present. The states requested leatherback-sized TEDs at all times to save adult loggerheads, but there was no response by NMFS to this request. The South Carolina example of “creating community collaboration” came when the sea turtle volunteers and commercial shrimp fishermen lobbied the state legislature to enlarge TED openings to 20 inches in 2002. In 2003, NMFS required leatherback-sized openings at all times. Lesson 6: Modelers that want to demonstrate a “TED effect” based on strandings should be aware of the history of local management actions, compliance and enforcement; “promulgated” does not mean “implemented.” Currently, the rate of decline in the sampled South Carolina nesting population in may be slowing. Although the number of strandings remains around 100, many are from vessel strikes and disease, not from shrimp fishery bycatch. And in-water data in the southeast may indicate an increase in the abundance of juvenile loggerheads compared to data from the late 1970’s. These three positive trends show the success of persistent sea turtle management. Many sea turtle biologists and conservationists are fighting similar battles for sea turtles throughout the world. Final Lesson: Use the other lessons wisely and... never give up.

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## **LOGGERHEADS AND LEATHERBACKS IN THE WESTERN INDIAN OCEAN\***

**George R. Hughes**

Sea turtle conservation work in the Western Indian Ocean started in 1963 and established that two species nested in South Africa. Responsibility for the initial protection was that of the Natal Parks Board, the provincial nature conservation authority. Protection since 1998 continues uninterrupted by the successor to the Natal Parks Board, Ezemvelo KZN Wildlife. The South African research attracted the attention of Professor Archie Carr and I was invited to become a foundation Member of the Marine Turtle Specialist Group. My perceptions and experiences of the first and second Marine Turtle Specialist Group meetings will be addressed briefly. The conservation programme has proved a success and has drawn support and interest from NGOs such as the Oceanographic Research Institute, Durban, WWF-SA and the African Wildlife Society, universities such as the Universities of Natal, Rhodes and Durban-Westville, local, regional and national governments and international instruments such as the RAMSAR Convention, the Convention on Migratory Species and the World Heritage Convention. The positive support of such a wide range of influential bodies has helped protect the nesting beaches from two severe threats; firstly the threat of a deep water harbour which resulted in a 10 year long annual transfer of 20,000 eggs 100 km south to safer beaches and secondly a mining venture involving the extraction of heavy minerals from the adjacent beaches. Successful conservation efforts on the nesting beaches have involved private citizens, local communities and the private sector and this has extended into neighbouring Mozambique. A broad but relatively brief overview of the synergistic roles played by the many role players will be presented along with the results of the now 46 year old programme which has reflected very positive growth in the number of nesting loggerheads, less spectacular growth in the leatherback population, which has now stabilised. Research has demonstrated that loggerheads come from 3500 km distant to nest in South Africa and that both species annually leak genes into the Atlantic Ocean where many of the leatherback females go to feed after nesting. The role of the Agulhas Current in the distribution of hatchlings at the beginning of their pelagic phase has been confirmed following a mark and release programme which has involved over 400,000 loggerhead hatchlings. Some emphasis will be placed on the role of the private sector and the necessity of all inclusive publicity campaigns. The importance of the South African programme lies not simply in its own merits but also on the influence it has had on other parts of the western Indian Ocean where today sea turtles enjoy widespread protection. There are now more

than 12 protected areas in the region where in 1969 there were none. Not every endeavour has met with success and the closure of the turtle farm in Reunion through the negative influence of NGOs was a personal disappointment and perceived as a lost opportunity. The fact that it has been replaced with an outstanding Exhibition Centre with expanding research influence in other parts of the region is commendable and encouraging. The role played by the South African turtle programme has been rewarding indeed as it has provided training and learning opportunities to countries throughout the western Indian Ocean and start-up guidelines to countries as far afield as Bangladesh, Kenya, the Islamic Republic of the Comores and Eritrea. It is concluded that the effort to protect the loggerheads and leatherback turtles nesting in South Africa has made a significant contribution to the global effort to ensure the survival of sea turtles and it has been a privilege to be associated with this endeavour.

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## **GREEN TURTLES IN AUSTRALASIA: LESSONS FROM 40 YEARS OF TURTLE MANAGEMENT?\***

**Colin J. Limpus**

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This year: 2009 marks the 40th anniversary of the first international meeting held to promote the global conservation of marine turtles. This 1st meeting of the IUCN Survival Services Commission Marine Turtle Specialist Group (MTSG) was held in Morges, Switzerland in 1969 under the leadership of Dr Archie Carr. For the first time, researchers and managers who were grappling with difficulties of marine turtle conservation in diverse parts of the globe were brought together to share knowledge and seek solutions in turtle management. Southeast Asia and northern Australia supported some of the great green turtle nesting populations of the world and fostered the development of modern turtle research and management up until the 1960s. That 1st MTSG meeting heard reports on green turtle research and management in Sarawak (Dr Tom Harrison), Sabah (Stanley de Silva), Peninsula Malaya (Dr John Hendrickson) and Queensland (Dr Robert Bustard). The first systematic tagging (mark-recapture) study of nesting sea turtles, at Heron Island, Queensland in 1929-1930 using copper carapace tags (Moorehouse, 1933), was a milestone in green turtle reproductive science. Tom Harrison in the early 1950s in Sarawak invented the stainless steel (monel metal) flipper-tag that facilitated turtle tagging studies on a routine basis. Armed with increasing understandings of turtle biology, managers in the different regions, in response to local customs, experimented with different approaches to sustainable use of turtles. In the Islamic dominated areas of Malaya (Terengganu), Sarawak and Sabah the local people did not normally eat turtles but collected turtle eggs in vast numbers for food. Traditional practice supported by British colonial administration in these areas saw the development of egg harvest license systems that by the 1950s were resulting in an approximately 100% take of the eggs laid at numerous rookeries. Those British colonies of the 1950s are now Malaysian States. Tom Harrison and John Hendrickson, in response to approximately zero turtle hatchling production over many years, started hatchery programs in Sarawak and Malaya. Based on the misconception that it only required two eggs to hatch to replace the adult female and male, these early hatchery programs only strived to bring 2% of eggs into protected incubation. By the 1960s, State-levied taxes from egg collection licenses were being used to fund the running of hatcheries and purchase eggs from egg collectors. In Terengganu, the conservation management of green turtles lagged behind the efforts made to conserve the leatherback turtle populations. Over the following decades, an increasing proportion of eggs laid at rookeries in Terengganu and Sarawak were protected for incubation – with the majority of green turtle eggs being protected by the 1990s. Hatcheries were also used at the Sabah Turtle Islands. However, to counteract the declining population of green turtles as a result of long term near-total egg harvest, Stanley de Silva as Forest Warden, made a dramatic change in turtle management practice and declared the three Sabah Turtle Islands as National Parks in 1969. These were the first National Parks declared in Asia to protect turtle nesting habitat. However, the local villagers living on these Turtle Island National Parks did not respect the protection laws for the green turtles and continued to harvest the eggs. Sabah's Forestry Department responded in the 1970s and depopulated the Turtle Islands and relocated the villagers to mainland Sabah. The Sabah Turtle Islands have continued to be strongly managed to the present time with regulated visitor access to the islands. The protected hatchery style of egg management was continued for these islands to minimize the illegal take (poaching) of eggs. Since the 1980s, controlled ecotourism with the nesting turtles has provided income for staff employment and management of these islands. In Queensland, the commercial fishers of European decent did not actively seek turtle eggs for food but harvested green turtles from coastal foraging areas as well as from nesting beaches. Turtles were sold in fish markets and numerous turtle soup factories had operated in Queensland since the 1800s. The Moorehouse study provided the basis for various changes in fisheries regulations that finally led to the 1950 declaration of a year-round closed season for commercial fishing for green turtles in Queensland and the subsequent closure of the turtle soup factories. Queensland in 1968 was the first

Government globally to pass legislation to protect all species of marine turtles. This protection does not apply for indigenous people taking turtles or eggs for traditional purposes. During 1948-1982, the major green turtle nesting islands of southern Great Barrier Reef were progressively declared as National Parks. Hatcheries were not used as a management tool for green turtle conservation in Queensland. Modern genetics studies show that each of these four populations represents an independent management unit. The long-term nesting census data from these four turtle populations now span more than 40 years (approaching a green turtle generation). Examination of the long term population trends show that the two management regimes that implemented strong conservation measures to minimize turtle mortality across significant parts of their respective populations now support increased green turtle nesting populations compared to four decades ago. Similarly, the management regimes that facilitated large scale egg harvest while protecting only a small proportion of the eggs within the management unit now support depleted nesting populations. These are only a few of the long-term managed sea turtle populations in the world. Now is an appropriate time to review and learn from the successes and failures of the diverse long-term management practices that have been applied to turtle populations.

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## **HAWKSBILL TURTLES IN THE IOSEA REGION: A REVIEW OF MANAGEMENT EFFORTS\***

**Jeanne A. Mortimer**

The tortoiseshell trade which extends back to the ancient civilizations of pre-dynastic Egypt, ancient China, and the Roman Empire has had an enormous and enduring effect on hawksbill populations in the IOSEA region and worldwide. During recent centuries the European colonial powers, especially the Portuguese, Dutch, French, and English played a major role in the shell trade (Meylan & Donnelly, 1995; Mortimer & Donnelly, 2008), with particularly intense exploitation in the 'East Indies' (i.e. modern day India, Indo China, Indonesia, Malaysia, and Philippines) which Parsons (1972) considered the world's most productive seas for tortoiseshell. In relative terms, the Japanese bekko industry is a more recent phenomenon dating back to the Edo period of 1700. But in modern times (post-1950) its impact on global hawksbill populations has been devastating due to the efficiency afforded by modern technology (i.e., the advent of the mask and snorkel, spear guns, and underwater torches), effective global transportation that linked Japanese buyers to remote sites, increased human population in coastal areas, and the exceptionally high price Japan was willing to pay for shell (Meylan & Donnelly, 1995; Mortimer & Donnelly, 2008). During the 1960s hawksbill take became so intense that annual imports to Japan exceeded 30 tonnes annually. Between 1950 and 1992, Japanese statistics document the import of shell equivalent to more than 1.3 million large hawksbills from around the world and more than 575,000 stuffed juveniles from Asia during 1970-1986 (Milliken & Tokunaga, 1987; Groombridge & Luxmoore, 1989). The global plight of the hawksbill in the latter half of the 20th Century was recognized by inclusion of the species in the most threatened category of IUCN's Red List since its creation in 1968 and the listing of all hawksbill populations on Appendix I of CITES since 1977. At the first meeting of the IUCN Marine Turtle Specialist Group in 1969 members expressed concern about the global over-exploitation. But, trade was maintained at exceptionally high levels for years while Japan continued to import shell under a CITES reservation until 1993, even though major trading countries had already acceded to CITES. Some countries attempted to moderate their hawksbill exploitation while still engaged in the bekko trade. In this regard, the Republic of Seychelles in the Indian Ocean provides an interesting case study. During the course of the 20th century Seychelles consecutively passed a series of laws and regulations in an effort to reduce the take. These included: establishing a system of record keeping that monitored exploitation and export (i.e., Declaration of Caret); restrictions on size (i.e., protection of small turtles), seasonal restrictions, protection of female animals, and a system of quotas. These efforts were largely ineffective. On the other hand, establishment of a series of nature reserves in Seychelles where turtles were protected from poaching and their nesting emergences were monitored produced better results. In fact, long-term monitoring was conducted at both protected and unprotected beaches at 22 of the inner islands of Seychelles, during both the early 1980s and the early 2000s. Nesting populations at two islands that had been well-protected since the 1970s increased several fold during a period of two decades; meanwhile, the nesting populations at 13 islands that had received no protection prior to 1994 declined by almost two thirds during the same period. When all 22 islands are considered together, the data indicate an overall decline of about a quarter of the total nesting population between the early 1980s and the early 2000s (Mortimer, 2004). It is noteworthy that the greatest increases in the protected nesting populations coincided with termination of legal export to Japan at the end of 1992 (Mortimer, 2004). A similar correlation was also noted in the Caribbean (Mortimer & Donnelly, 2008), which highlights the importance of international trade restrictions at the global level. Once Japan stopped importing shell, Seychelles Government enacted legislation in 1994 protecting all

species of sea turtles, and purchased and subsequently destroyed virtually all existing stocks of raw shell (Mortimer, 1999). Although much reduced from pre-1992 levels, domestic and international trade in shell continues in many IOSEA countries (notably in parts of Southeast Asia and Madagascar), much of it involving tourists and persons buying in bulk for export to Asian countries and communities. There is also evidence that some Japanese dealers have continued to import illegally and expressed interest in acquiring Indonesia's remaining stockpiles of bekkō (TRAFFIC Southeast Asia, 2004; van Dijk & Shepherd, 2004). Intense levels of egg exploitation continue in many parts of the world, especially Southeast Asia where it approaches 100% in many areas (esp. Indonesia). Adult and juvenile hawksbills are killed for meat in some countries where it may be consumed by people or used by fishermen as shark bait (Mortimer & Donnelly, 2008). A relatively new problem is that of Chinese fishing vessels that capture and embalm many hundreds of large hawksbills at sea in the waters of southeast Asia (especially Malaysia and Indonesia) (van Dijk & Shepherd, 2004; Mortimer & Donnelly, 2008). Population decline caused by directed take can sometimes be reversed by eliminating key sources of turtle mortality (Mortimer & Donnelly, 2008). But, destruction of turtle habitat, especially nesting habitat impacted by unregulated coastal development, is a more insidious, intractable, and irreversible problem. Throughout the IOSEA region major nesting populations are threatened by tourism and/or petrochemical development. Particularly vulnerable are daytime nesting hawksbills of the western Indian Ocean. Mitigating measures can be partially or temporarily effective. But, in order to ensure the survival of turtle populations for posterity (i.e., decades or centuries into the future) we need to set aside core areas of pristine nesting habitat now as sanctuaries where natural processes can unfold in perpetuity without human interruption or the need for manipulation.

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## **FOUR DECADES OF PROGRESS. HOW ARE THE RIDLEYS DOING?\***

**Peter C. H. Pritchard**

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I was a youth of 20 when I first learned from a brief note in the weekly *New Scientist* that Archie Carr's famous "Riddle of the Ridley" had been solved: Kemp's ridleys really did nest like other turtles, contrary to widespread belief otherwise. Well, it was not quite like other turtles, although they did also lay a hundred or so spherical eggs with flexible shells that they buried in tropical beaches. But the concept of laying them in the middle of the day was a novel approach; all other species nested by night. The urgency with which the mother turtles hurried ashore and then hurried back after equally speedy nest construction and oviposition also contrasted sharply with the labored gait of nesting greens or leatherbacks; and – most dramatic of all – instead of arriving on the beach one by one, it seemed that the whole world population of adult females – perhaps 40,000 – came ashore in one place (the beach near Rancho Nuevo, in Tamaulipas, Mexico) and at one time. Archie called it 'Panspecific Reproductive Convergence'. A 16 mm film was taken to prove this unlikely story, and a new word 'arribada' entered the lexicon of cheloniology. I was still preoccupied with ridleys and arribadas in 1969 when IUCN convened the first meeting of the newly created Marine Turtle Specialist Group at its headquarters in Morges, in Switzerland. This was the first chance that we few sea turtle people had ever had to meet each other, face-to-face. The older generation was represented by Archie Carr and Leo Brongersma; those of later middle years were John Hendrickson and Tom Harrison, younger still were Harry Hirth, Joop Schulz, Stanley de Silva, E. Balasingham, Antonio Montoya, and callow youth was represented by a formidable trio of Robert Bustard, George Hughes, and myself. Female turtlers were a minority of one: Mary Margaret Goodwin, an Assistant Secretary in the Pentagon. The changes that have occurred, both organizationally and biologically, since that 1969 meeting have been astonishing. Today, the infrastructure and resources for marine turtle conservation and science include the C-Turtle List-Serve; [seaturtle.org](http://seaturtle.org); WIDECAST; the Archie Carr Center at the University of Florida; the Caribbean Conservation Corporation; the Marine Turtle Newsletter; a shelf full of turtle books, monographs and gray literature many yards long; national research and conservation efforts, governmental and private, in virtually all sea turtle range-states; the Chelonian Research Institute; a massively enlarged IUCN Marine Turtle Specialist Group, ad hoc recovery teams and working groups galore, and of course, the mightiest of all, the International Sea Turtle Society and its annual symposia, originally confined to a wandering-ministrel itinerary up and down the southeastern shores of the USA, but now truly intercontinental. The challenge for a young or newly-fledged sea turtle person is to decide which slice of this enormous pie to make his own. Some pick a species, some pick an island, some select a specialized conservation approach, ranging from head-starting to community involvement, others may choose a country, or geographic area, for long-term monitoring, and an increasing number are attracted to technological approaches – satellite tracking, crittercams, data logging, PIT tagging, DNA sequencing, and so on. What do the turtles themselves think of all this? Has all this attention helped them? I decided to work with ridleys. Fate made the real decision. In 1964, on my first trip to the tropics I encountered *Lepidochelys olivacea* nesting in the south Atlantic, specifically in British Guiana, now Guyana – the ostensible "Pacific" ridley caught nesting in the Atlantic! Almost simultaneously *olivacea* was also discovered nesting in Surinam, and in 1965 I discovered a small but legitimate nocturnal arribada of this species at

Eilanti, in Surinam. Egg collection by local Caribs was approaching 100%, but by instigating a two-year egg-buying program at the beach, we set aside about 300,000 eggs per year for hatching. Today, the Guyana ridley population is negligible and the Surinam arribada is decimated to just a handful of animals. Perhaps this unfortunate outcome was related to the egg take, but beach erosion was also part of the equation, and also a huge mud flat built up in front of Eilanti, effectively preventing nesting. But, looking to the east, we find olive ridleys starting to form small arribadas near Cayenne, French Guiana, and in Sergipe (Brazil) the nesting numbers are leaping upwards. My sense is that the shift was natural, brought about by one of the most shifting, fast-changing shorelines in the world. Elsewhere in the western Atlantic, Kemp's ridley has for decades been called the world's most endangered sea turtle, although it is also the only one that has been on an upward global trajectory for nearly 20 years. This is a result of what I call "good conservation and bad science," whereby you do not pause to dissect the problems minutely, but you immediately do everything possible to enhance the species even though you may end up not knowing which factor was the operative or effective one. I became involved with the beach protection effort for this species in 1968, when Mexico already offered beach protection but lacked vehicles to deploy the armed marines responsible for law enforcement. I continued this solo effort for two more years, and after a gap the American contribution to the program was re-launched in 1978 in the form of an intergovernmental effort that continues to this day. It is always dangerous to identify a conservation program as a definitive success, but the Kemp's ridley effort certainly comes close. I have spent many weeks observing or waiting for the big arribadas of olive ridleys at Ostional and Nancite in Costa Rica and spent several seasons working for the closure of the ridley slaughterhouse at Puerto Angel, Oaxaca, Mexico. The upshot of these involvements has been puzzling indeed. The Nancite turtles have diminished steadily despite total protection. The Ostional turtles have held their own even though millions of eggs are collected for human use during the early nights of an arribada. The Oaxaca operation was closed down and, subsequently, the nesting population surged to about a million nests per year within a few seasons. Theoretical explanation of these outcomes remains elusive, but one implication is that it is unwise to consider a very large turtle population to be an inherently healthy one; an overstock of nesting ridleys may result in minimal hatchling production, and be an harbinger of population collapse rather than population vigor.

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## **40 YEARS OF SEA TURTLE CONSERVATION: WHAT WORKED? WHAT DIDN'T\***

**Perran Ross**

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I start with the objective that a keynote address should be informative, amusing and provocative. My first contention is that sea turtle conservation has clearly worked. The status of sea turtles is no worse than it was 40 years ago, and in some cases much better. We know more, we understand better and we have a vastly expanded network of people involved. Severe challenges remain, more research is needed and our continued effort is required, but we need not despair. My next observation is that some aspects of sea turtle conservation have the appearance more of religion than science. We reify concepts, deify individuals and easily sink into dogma and orthodoxy. We adopt and even encourage a strongly emotive perspective about our study animals to an unusual degree, matched only perhaps by those who work on marine mammals. We implicitly and explicitly claim that sea turtles are 'different' - which is nonsense. They are bound by the same physical laws and selective pressures as every other organism. This has one unfortunate consequence that we assume sea turtle populations do not fluctuate, although why this should be so is unclear, when every other organism studied clearly does fluctuate in numbers. This leads us to interpret every measured or suspected decline as immanent extinction and every miniscule increase as recovery. This has distracted us from useful analysis of population fluctuations and their causes. The result of this thinking has been the tacit adoption of very risk averse approaches to sea turtle conservation. We have been reluctant to probe the system. I believe we are overdue for a paradigm shift from sea turtles as delicate organisms on the brink of extinction to sea turtles as robust survivors in a changing world. Among numerous dogmas past and current is the widely held belief that the life history strategy of sea turtles makes them uniquely vulnerable, when the opposite is the case. If slow maturing long lived organisms were as sensitive to mortality as is claimed - selection would eliminate this strategy and there would be none. The self evident persistence of sea turtle populations in the face of quite severe exploitation suggests that there is something inaccurate about our models and theory on this point. In fact long lived organisms have a uniquely robust life history and when combined with the quite remarkable fecundity of sea turtles, unequalled among non- fish vertebrates, makes for a tough group of survivors. Another dogma that has confused us in the past is the unthinking generalization of truths from one sea turtle species to another. In fact the extant sea turtles species are not particularly closely related to each other and it should not surprise us that their biology and ecology are different. Our response to challenges to these and other

dogmas has often been to demonize the heretics. In this we follow a very well known pattern of scientific change and revolution where old dogmas are defended long after they should be and new insights resisted because of their source or their proponents. This has led to controversy, which bothers some people, but not me. For the supporters and researchers of such inoffensive creatures as sea turtles, sea turtle scientists become quite remarkably savage when their shibboleths are attacked. While these outbreaks of aggression are distressing, they are ultimately productive in resetting our assumptions. I will discuss recent and historic examples from the Red List process, Orissa port developments and the bekko trade. We continue to suffer from a couple of delusions that are preventing us from seeing clearly and acting effectively. One of these I call “Information deficit theory” which assumes that if everyone knew what I know, they would think as I think and act as I act, which just ain't so. People think and act based on their values, their experience and their social setting. As we better integrate this thinking into our conservation, so it will work better. The other is what I call “Prescriptive rather than Adaptive management”, which takes the reductionist position that if I understand enough about this system, I can deconstruct and understand its operation and predict its behavior and therefore direct action to predictable outcomes. A wealth of systems analysis, chaos theory and empirical testing shows us that this approach has limited application in complicated open systems. This symposium had its origins in a small group of heretics, concerned that their challenges to the dogmas of the day were being suppressed by an orthodox hierarchy. Despite the quasi religious appearance of our science, our tendency to dogma and risk aversion perhaps balanced by recurrent outbreaks of heresy and controversy, the enterprise has muddled through to an acceptable success rate. Huge challenges are upon us or immanent, foremost among these climate change and continuing coastal development. We need to recognize the nature of sea turtle conservation and apply these insights to effective future action.

## **MIGRATION AND MOVEMENT**

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### **SATELLITE-TRACKED MOVEMENTS OF LEATHERBACK SEA TURTLES, *DERMOCHELYS CORIACEA*, FROM SOUTHEASTERN BRAZIL**

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The movements of four leatherbacks from the Southwest Atlantic nesting colony of Brazil were tracked using satellite telemetry (3 from a nesting ground in the State of Espírito Santo tagged in December 2005, and one caught in a driftnet off the coast of the State of São Paulo in February 2006). One of the nesting females died after entanglement in a coastal driftnet in the mouth of Doce River 26 days after deployment. Two of the other turtles were tracked for 383 and 406 days. The fourth turtle, tagged approximately 200 km off of the southeastern Brazilian coast, was tracked for 97 days. Internesting movements extended along 300 km of the coast, moving over 100 km on either side of known leatherback nesting beaches. Both remaining females tagged at the nesting grounds migrated southward: one moved off-shore to oceanic waters before turning west and traveling to the State of Rio Grande do Sul, and then on to Uruguay; the second moved along the continental shelf to the La Plata river estuary, between Uruguay and Argentina. Eventually both turtles moved northward to the coast of the State of São Paulo. One transmitter ceased transmissions for 5 months and then started transmitting again 5 months later when the turtle reached the La Plata. The second tagged female moved from São Paulo coast to international waters and moved across the south Atlantic Ocean to within 350 km of the coast of Angola, Africa. The third turtle (tagged after capture in the driftnet fishery) moved eastward to oceanic waters over 600 km from the coast. She then moved northward, reaching the State of Rio de Janeiro, then moved on to the State of Bahia, and then southward, towards the State of Espírito Santo, when transmissions ceased. The latitudinal movements of these turtles involved frequent speed shifts, suggesting feeding activity along the migrations between the nesting area and the southern recorded limit, in the La Plata River estuary. Despite the few turtles tracked (only four turtles nested in Espírito Santo during 2005/06 season), the time spent in Uruguayan-Argentinean waters (15 to 55 days), suggests that this region is an important feeding ground for turtles that nest in

southeastern Brazil. The trans-Atlantic movements of one of the turtles: moving to African foraging areas is similar to such movements in the North Atlantic leatherbacks nesting in the Caribbean. Finally, interesting movements revealed a wider use of waters adjacent to nesting grounds than previously inferred from flipper-tagging, and therefore conservation measures must involve “buffering” areas both northward and southward.

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## **USE OF THE GULF OF VENEZUELA WATERS BY FOREIGN SEA TURTLES: INFERENCES FROM 45 YEARS OF TAG RETURNS**

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Sea turtle feeding grounds have been vigorously incorporated into conservation efforts in recent years. The Gulf of Venezuela (GV) has been recognized as an important feeding ground for five sea turtle species from the Venezuelan coast and the Caribbean. Juveniles, subadults and adults from several Caribbean rookeries have been reported, suggesting that different sea turtle populations utilize the GV. However, the GV is also the home of indigenous Wayúu, whose illegal trade and consumption of sea turtles is deeply rooted in their magical-religious belief system. Therefore, this feeding ground on the GV coast has been included in the "Venezuelan Sea Turtle Recovery Action Plan". The objectives were to compile all tag return data and look at the habitat use of sea turtles at different life stages in the GV. We reviewed scientific reports, theses and interinstitutional mail. Additionally, we conducted semi-structured interviews with fishermen to collect data on code, species, date and place of recovered tag. A total of 30 tags have been recovered from four sea turtle species: *Chelonia mydas* (86%), *Eretmochelys imbricata* (7%), *Caretta caretta* (3%) and *Lepidochelys olivacea* (3%). The majority of tag recoveries occurred along the northern GV, possibly influenced by the high occurrence of sea turtle poaching there. The most common tag returns were from green turtles tagged in Costa Rica (19), but tags were also recovered from turtles originally tagged in Bermuda (3), Florida (1), Colombia (1) and Panama (1). The farthest tag return was from a subadult loggerhead from Los Azores (Portugal). Tag returns from green and hawksbill turtles came from Aves Island and Los Roques Archipelago, Venezuela. Two tag recoveries came from within the GV, one from a subadult green turtle tagged in April 2007 and recovered dead in September 2007, and another from a juvenile hawksbill turtle tagged in November 2003 and recovered dead in December 2003. These last two tag returns suggest that foraging green and hawksbill turtles have been using the GV also as developmental habitat. An analysis of these results confirms that GV waters are used by sea turtles from several places in the Caribbean.

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## **EPOXY USED IN SATELLITE TRANSMITTER ATTACHMENT: TOO HOT, TOO COLD, OR JUST RIGHT**

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Satellite transmitters are attached to sea turtles as a method for determining sea turtle movement patterns, migration routes and foraging habitats. Attachment methods vary between species and researchers, but fiberglass or epoxy are two different compound adhesives that are commonly used for hard-shelled species. For both methods, there is a trade-off between curing time and heat generated. Fiberglass has a high heat reaction potential between resin and catalyst that is a concern of many researchers. Epoxy has been used widely in recent years as a lower heat alternative with positive reviews. However, the lower heat epoxy has a longer curing time. We ran comparative tests of the curing time and heat produced from various, readily available epoxy products. A preliminary experiment tested equal quantities of eight different epoxy products on an adult loggerhead carapace to determine the curing time and heat derived from each product. Temperature loggers were adhered to the underside of the carapace, beneath each 10cm x 10cm test site, to record the amount of heat that was transmitted through the carapace. Meanwhile, ‘touch-tests’ were conducted to record operational benchmarks of the curing process (i.e. wet - tacky - dry). A similar follow-up study utilized mock

transmitters and a layered epoxy application process to better represent satellite transmitter deployment. Temperature loggers were placed on the underside of the carapace directly under and adjacent to the transmitter position. In addition, the heat reaction of the epoxy was monitored externally by laser temperature reader. Results from the epoxy products are provided, including recommendations, possible alternatives, and warnings for those products tested.

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## **TURTLE IDENTIFICATION FROM DIGITAL PHOTOGRAPHS: AN ARTIFICIAL INTELLIGENCE APPROACH**

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Sea turtle population studies have historically relied on various methods to identify recaptured turtles both temporally and spatially, including: surgically implanting passive integrated transponders (PIT); mutilation marking; or by applying metal or plastic tags through soft tissue or carapace. For a range of reasons (tag loss, mis-identification, cost, exposure to disease, increased risk of entanglement in marine pollution or ethical) these approaches have not been entirely successful. Morphometric feature recognition analysis of sea turtle digital images has the potential to offer an easy, minimally intrusive, low-cost, and highly reliable alternative. Like a human fingerprint, the facial scutes of many sea turtle species are very distinctive, stable, and uniquely identify individuals. This paper presents the design of a prototype software system that can delineate the boundaries and recognise pigment patterns of post-ocular scutes in digital photographs of captured turtles. The program then uses a feed-forward neural network, trained by backpropagation, to compare scute patterns to a database of turtles captured and photographed in previous surveys. The prototype system has been successfully applied to green turtle populations in the northern Great Barrier Reef with a high level of accuracy. Individual turtle data can be stored in an electronic database indefinitely. While the methodology may in time be applied to other species, it has the clear potential to enhance population biology studies of green, hawksbill and flatback turtles.

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## **MOVEMENT OF SEA TURTLES BETWEEN NESTING SITES AND FEEDING GROUNDS IN THE SOUTH WEST INDIAN OCEAN: REGIONAL MIGRATORY KNOWLEDGE AND INTERACTION WITH OPEN SEA FISHERIES FOR MANAGEMENT ISSUES**

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In the year 2000, countries bordering the West Indian Ocean requested assistance in the management of the living resources and associated habitats of their shared marine ecosystems. In response, under the Global Environmental Facility (GEF), the World Bank initiated the development of a multi-national fisheries management and development programme called the South West Indian Ocean Fisheries Project (SWIOFP) which included 9 different countries: Kenya, Tanzania, Comoros, Mozambique, Seychelles, Madagascar, South Africa, Mauritius and La Reunion (France). One component of the program relates to the interaction between sea turtles and open-sea fisheries in the WIO. Even though green turtle behaviour is locally well known during the feeding and reproduction seasons, the lack of data on the migratory routes between the successive habitats isn't enough to take appropriate conservation measures at the regional level. We still do not understand the spatial dynamics of that migratory species which moves hundreds of kilometres between feeding grounds and nesting sites. Therefore, regional cooperation between the concerned countries is necessary for protecting these areas. Since July 2008, SWIOFP began studying the movements of green turtles between nesting sites and sea grass beds in the WIO and their interactions with fisheries within an ecosystem approach. More than 100 satellite transmitters will be attached to sea turtles at different life stages and from different localities.

Interaction with open seas fisheries will then be estimated using a probabilistic model developed by the Australian team that used sea turtle abundance, tracking, environmental, oceanographic and fisheries data.

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## **PHOTO-IDENTIFICATION OF MARINE TURTLES: AN ALTERNATIVE METHOD TO MARK-RECAPTURE STUDIES**

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Photo-identification can be an alternative to recapture studies for the identification and tracking of individuals over time. It might be used to complement other invasive methods of tracking (e.g. if a tag is lost) or it may eventually replace them. We investigated the suitability of this method for green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) at Reunion Island, Mayotte and Glorieuses (South West Indian Ocean). We developed a code for individual identification based on the location and form of the scutes in the head profiles of turtles. We also developed a database to manage photos and sighting information, permitting quick individual identification using code recognition. Analyses of head profile pictures taken from marine turtles at the three study sites proved adequate for marine turtle tracking studies. This technique requires the participation of scuba divers for the collection of photos and for sighting information on a grand scale. It may therefore help to increase public awareness for the conservation status of this endangered species.

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## **MARINE TURTLE HATCHLING ORIENTATION: CONTRASTING MOVEMENTS OF DIAMONDBACK TERRAPINS AND SEA TURTLES**

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Previous studies have investigated the sea finding orientation of sea turtle hatchlings, and a number of cues (i.e. light, openness of horizon, and slope) have been explored. These cues lead sea turtle hatchlings to move quickly down the beach and into the surf. However, hatchling orientation in another marine turtle, the diamondback terrapin, is not well understood. It is believed that terrapins, after emerging from the nest during the day, travel in the opposite direction of sea turtles toward marsh vegetation. Burger (1976) observed that terrapin hatchlings used slope as a possible cue. But, hatchlings preferred moving to close vegetation over venturing down a slope. Also, no compass orientation was observed in hatchlings that emerged on flat sand areas. The current study examined the behavior of hatchling terrapins to elucidate potential orientation cues. Individuals were started on flat areas on their natal beach and given the choice of going towards open water or marsh cover, and two behaviors were overwhelmingly observed. Most hatchlings either moved toward marsh vegetation or buried themselves in the sand. These results display an interesting contrast that exists in marine turtle orientation, as sea turtles and terrapins experience similar cues but move in opposite directions.

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## **POST-NESTING MIGRATIONS OF HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) IN THE STRAIT OF MALACCA\***

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The hawksbill turtle (*Eretmochelys imbricata*) nesting population in the state of Malacca is the second largest in Malaysia with average nesting numbers of 367 annually (based on 2004-2008 records from the Department of Fisheries). Though considerable effort has been expended towards egg protection and hatchery management, where they feed and their migration range remained a mystery as virtually nothing was known about their foraging habitat and migration patterns. In 2006, satellite telemetry research was initiated to follow the migration of hawksbills after nesting along Malacca shoreline. As of 2008, a total of eight adult female hawksbill turtles were satellite tagged at four prime beaches. Four Kiwisat 101 Platform Transmitter Terminals (PTTs) were deployed on Upeh island, two at Kem Terendak and one each at Padang Kemunting and Tanjung Dahan. Each nested for at least three to six times prior to the start of their migration. All eight turtles tracked revealed a similar migration pattern; travelling southbound in the Strait of Malacca even though their nesting beaches varied, some of which are more than 30 kilometres apart. Six turtles were tracked to the waters of the Riau Archipelago, Indonesia, whilst two turtles were tracked to the southern waters of Singapore. The range of distance travelled is from 213 to 320km (straight line distance). The migrations itself took place between a range of 9 to 24 days, after which the momentum of their movements slowed dramatically indicating that the turtles have reached their foraging grounds where signals remained for a range of 7 to 240 days with limited movements that ranged from 4.5-58 kilometres radius respectively (as of time writing this abstract). The overall duration of signals actively transmitted from attached transmitters ranged from 18 to 277 days. The discovery of these satellite tracked hawksbills' foraging grounds surrounding the Riau Archipelago suggests that the waters encompassing this geographical region is of immense importance to the nesting population in Malacca and probably to other nesting populations as well. Their survival would depend on the conduciveness of its environment to provide a suitable foraging ground, thus a regional cohort effort on ensuring thorough protection for the hawksbills in these waters is needed. This study was made possible by the funding of WWF-Netherlands, the permission of the Malacca state Department of Fisheries, and the help of Army personnel at Terendak Army Camp and the many volunteers of WWF-Malaysia. A special thanks to the International Sea Turtle Society, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund) for their contribution to the travel grant.

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## **A TALE OF TWO BODY TYPES: STABILITY IN SWIMMING LOGGERHEAD (*CARETTA CARETTA*) AND GREEN (*CHELONIA MYDAS*) SEA TURTLE POSTHATCHLINGS\***

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Posthatchling *Chelonia mydas* and *Caretta caretta* overlap spatially and temporally and share numerous cheloniid characteristics, but still differ dramatically in morphology. From a dorsal perspective, the loggerhead carapace is tear-drop shaped, while the green turtle carapace is more oval in outline and their bodies are more dorsoventrally compressed. Additionally, loggerhead posthatchlings possess carapacial and plastral keels, while greens lack keels. Furthermore, green turtles have relatively long, thin (high aspect-ratio) flippers while loggerheads have relatively short, broad (low-aspect ratio) flippers. These differences suggest that hydrodynamic performance may differ between the two species. Since sea turtles are highly migratory animals, it is important for them to swim with maximum efficiency, and wasted movement during locomotion costs energy. Here we test the hypothesis that the morphological differences in body shape have functionally significant effects on swimming stability. Synchronized lateral and ventral-view videos

were collected from posthatchlings of both species as they swam along a linear path in an aquarium. Several landmarks on the body, shell, and flippers were digitized and were subsequently used in orthogonal two-dimensional analyses to quantify and compare four components of stability (yaw, sideslip, pitch, and heave) at different points during the limb cycle. Of the four stability measures, only maximum downward pitch differed significantly between the two species, being greater for loggerheads. Thus, while several interspecific morphological differences exist, they have little effect on sideslip, heave, and yaw. Furthermore, unlike in other vertebrates where keels have been shown to enhance swimming stability, the data collected for pitch suggest that the keels of posthatchling loggerheads do little to enhance stability. Powerstroking is an oscillatory flipper movement and thus should be related to oscillatory displacement of the body. Heave showed the strongest oscillatory pattern. For both species, downstroke produced an upward heave and upstroke produced a downward heave, although differences in the lag between limb and body motions were evident. While turtles in this study were tested under controlled conditions, instability would likely be magnified in a natural environment where forces other than limb motion act on the animal. As a result, greater differences may be observed between the two species under such circumstances. The similarities in stability observed between loggerhead and green posthatchlings indicate that in spite of morphological differences, both species attain similar levels of stability during swimming. This is likely the result of the animals making compensatory movements with their heads, stroke angles, or steering. Loggerheads incur greater pitching during power stroking, which may add energetic costs to their swimming. Such costs are likely reflected in the natural history of the species.

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## WHERE DO MEDITERRANEAN LOGGERHEADS STAY?

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The loggerhead turtle (*Caretta caretta*) is the most common sea turtle species in the Mediterranean Sea, even though nesting sites are confined predominantly to the eastern shores. In particular, the Northern Adriatic Sea and the Gulf of Gabès are large neritic zones known to be suitable foraging sites for residing neritic-stage juveniles and non-breeding adults. Although the development of satellite telemetry in recent years has permitted substantial progress in understanding various aspects of turtle life cycles, the non-breeding phases are still poorly studied, especially movements and at-sea behaviour of juveniles and sub-adults. Available data on the distribution and movements of Mediterranean loggerheads are rather scarce and based upon analyses of tag returns and by-catch reports, while satellite tracking has only been applied in a few cases. The purpose of this study was to investigate the at-sea behaviour of juvenile and sub-adult loggerheads tracked by satellite in various regions of the central Mediterranean Sea, comparing the movement patterns displayed in different geographical areas and ecological conditions. Fifteen late juvenile loggerheads were tracked during their movements after release in three zones around Italy: the Northern Adriatic Sea, Northern Tyrrhenian Sea and Sicily channel, around Lampedusa Island. All turtles had been incidentally caught and released in the same region, and had been kept and, if necessary, recovered by different Italian Rescue Centres. Turtles were followed for periods ranging from 38 to 451 days, during which they remained within the Central Mediterranean basin. Some turtles covered large distances, up to over 7,500 km. Tracked turtles displayed a number of different behavioural patterns, such as prolonged residences in fixed neritic locations, seasonal migrations towards southern regions, wandering circuitous movements over large neritic and oceanic areas, and overwintering behaviours at high and low latitudes with long-lasting dives. The integration of location data with remotely-sensed oceanographic information indicates the main role of sea surface temperature (and, to a lesser extent, of chlorophyll concentration) in determining the kind and extent of turtle movements and behaviour. The reconstructed movements have confirmed the importance of the Gulf of Gabès and of the North Adriatic Sea as optimal foraging grounds for loggerheads in the Mediterranean Sea. Despite the fact that the North Adriatic Sea is the coldest area in the Mediterranean, loggerheads may reside there also during the winter, although many tracked turtles did migrate southward as the cold season approached. These findings also highlighted that other foraging areas (i.e. the Northern Tyrrhenian Sea, the Gulf of Naples and the Ionian Sea) are being used by juveniles which frequent the coastal shelf, the only neritic habitats available to them in these regions. This work highlights the importance of satellite tracking studies for at-sea

behaviours and migrations of juvenile loggerheads. The integration of tracking data with remote sensing information has highlighted the importance of environmental factors in determining the overall behaviour of turtles.

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## **MIGRATORY CONNECTIVITY AND CRITICAL CORRIDORS IN MEDITERRANEAN GREEN TURTLES\***

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There is a relative paucity of data regarding the at-sea distribution and behaviour of the Mediterranean population of the green turtle, *Chelonia mydas*, which is of extreme conservation concern. Here we report on an extensive programme to track post nesting females from multiple rookeries (n=10 from Northern Cyprus; n=8 from Turkey) and reveal a number of important insights into the ecology of the species. First, we highlight what are likely to be several key seasonal migratory corridors for this species, including the coastal waters of Cyprus, Egypt-Libya, Turkey-Syria-Lebanon and pelagic areas between Cyprus and Turkey and between Cyprus and Egypt/Libya. Second, although foraging areas are found in at least 3 nations, they are discretely clumped in space with a minimum of 80% of individuals thus far tracked located in 4 discrete areas in the waters of Lebanon, Libya (n=2 sites) and Turkey (3 of these areas host turtles from rookeries in Cyprus and Turkey). The individuals breeding in a given year are not randomly drawn from the different foraging areas and we highlight spatiotemporal correlation in the foraging grounds producing breeders in a given year. This suggests not only a strong influence of local conditions on the probability of breeding but also underlines how multiple years of tracking as well as enhanced sample sizes are likely needed to define key foraging areas using satellite tracking.

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## **GEOGRAPHIC DIFFERENCES IN MIGRATORY ACTIVITY BY HATCHLING LOGGERHEADS (*CARETTA CARETTA*): WHAT IS THE CAUSE?**

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Loggerhead sea turtles nest with almost complete fidelity on either side of the Florida peninsula. The hatchlings that emerge from those nests swim in opposite directions to begin their oceanic phase of development. Hatchlings from Florida's East coast probably use the Gulf Stream and North Atlantic gyre for transport to nursery areas on the opposite side of the North Atlantic basin (near the Azores, Canary Islands, and Madeira). Hatchlings from Florida's West coast may leave the Gulf of Mexico to reach the same nursery areas, although it is unclear at the present time whether that is, in fact, what they do. What has been established is that the hatchlings from each coast differ in the expression of their migratory activity. During the first 6 days of migratory swimming, West coast hatchlings are significantly more active, especially at night, than the East coast hatchlings. This difference might be related to the greater distance West coast turtles must swim to reach surface currents used for transport out of the Gulf of Mexico and into the Atlantic Ocean basin. The purpose of this study was to determine how these differences in migratory behavior develop. One hypothesis is that both populations are phenotypically plastic and possess genotypes that enable them to determine their coastal location during development and modify their migratory behavior accordingly. An alternative hypothesis is that hatchlings from each coast differ genetically. If so, then their behavioral differences are inherited and will persist regardless of the coastal environment they experience during development. To distinguish between these alternatives,

we conducted a classical “garden transplant experiment” in which we moved nests within 12 h of deposition between two sites (Boca Raton on the East coast and Sarasota on the West coast of Florida). These *translocated* nests were the experimental groups. We also had two groups of controls: nests from each coast left in place (*in situ* controls) and nests that were moved from one part of the same beach to another (*relocated* controls). After emerging, six hatchlings were collected from each nest and their activities were monitored for six days under identical laboratory conditions. To our knowledge, this is the first experimental design that teases apart the underlying mechanisms of behavioral differences within marine turtle subpopulations. The results are potentially important for understanding how new subpopulations of marine turtles become established. Thus far, that process has only been considered from the perspective of founder females nesting in new locations. However, their hatchlings must also survive by migrating successfully away from that location.

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## **HORIZONTAL AND VERTICAL HABITAT UTILIZATION OF MIGRATING LEATHERBACK TURTLES IN THE NORTH PACIFIC: PRELIMINARY ANALYSIS WITH OCEANIC CURRENT DATA**

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To understand horizontal and vertical habitat utilization of migrating leatherback turtles, we tracked post-nesting migrations of female leatherback turtles in the North Pacific for approximately 90 days. ARGOS transmitters and pop-up archival transmitting tags (PATs) were attached to three nesting females at Jamursba-Medi and Wermon rookeries (Papua Island, Indonesia; 0°21'S 132°33'E) in August 2006: ARGOS transmitters provided horizontal location every two days, and PATs collected hourly frequency distribution of swimming depths summarized in 11 bins (0-10, -20, -40, -60, -80, -100, -150, -200, -300, -500 and 500 m <). The three turtles took different migration routes: an eastward route toward the Hawaiian Islands (Turtle #1), a northward route toward Japan (Turtle #2), and the middle route where the turtle moved eastward along the 10°N line (Turtle #3). Using oceanographic data provided by AVISO, we analyzed the relationships between the horizontal movements and sea surface currents. Turtle #1 moved eastward in the direction of the eastward flowing Equatorial Counter-current with mean migration speed exceeding the velocity of surface current (Turtle #1: 88.1 cm/sec; sea current velocity: 39.8 cm/sec). Turtle #2 overpassed several eastward and westward currents while it took northward route, but the movement of Turtle #2 indicated little influence of sea currents except for the slightly meandering track (Turtle #2: 41.3 cm/sec; current velocity: 21.5 cm/sec). Turtle #3 moved against the North Equatorial Current with a mean speed of 31.6 cm/sec, while the current flowed westward at a mean velocity of 20.3 cm/sec. Mean relative migration speeds in which velocity components arising from the sea currents were removed from the apparent speed were similar to each other (49.9, 41.6 and 48.8cm/sec in Turtle #1, #2 and #3, respectively) in contrast with the difference between their apparent speed. The frequency of depth data indicated that the three turtles spent the majority of their time in depths less than 100 m. However, diving activities deeper than 200 m were also recorded. Our results showed that post-nesting female leatherback turtles moved rather irrespectively of sea currents once they oriented on the direction of their migration. The present study provided the first demonstration of vertical habitat use of the leatherback turtle in the Northern Pacific. Closer examination of depth information would reveal the feeding activity of female leatherback turtles during their post-nesting migration.

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## **MARINE TURTLE-FISHERIES INTERACTION MITIGATION TRAINING, DATA COLLECTON ACTIVITIES AND SATELLITE TELEMETRY IN THE REPUBLIC OF THE MARSHALL ISLANDS**

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The Marshall Islands Marine Resources Authority (MIMRA) is the primary agency responsible for the regulation and management of living and non-living marine resources in the Marshall Islands. They have increased activities pertaining to fisheries-turtle interaction mitigation training in the MIMRA-led observer program, and have permitted Women United Together in the Marshall Islands (WUTMI) to conduct a turtle salvage, data collection and skin sampling project to characterize and determine stock composition of *Eretmochelys imbricata* and *Chelonia mydas* in the Marshall Islands. A collaborative effort between JIMAR/NOAA Fisheries Service Pacific Islands Regional Office, MIMRA, and WUTMI included an expedition to Erikub Atoll where satellite transmitters were affixed to post nesting green turtles to determine migratory pathways and foraging grounds. MIMRA conducted training from 2005-2007 to increase awareness of observers and the Majuro-based fishing industry in documenting marine turtle-fisheries interaction. By the end of 2007 it was apparent that training had been absorbed by observers as witnessed by Secretariat of the Pacific GEN-2 forms being filled out with more detail than in previous years. Observers also photographed bycatch turtles. MIMRA faces challenges in continuing to train, assist and encourage observers to manage a multitude of tasks and much carryon gear. The WUTMI turtle data collection project was conducted by five women stationed in Majuro, Wotje, and Ailuk Atolls between October 2007 - September 2008. WUTMI opportunistically collected data and samples from turtles or turtle remains that had been used for food or cultural purposes as allowed under Marshallese laws. Turtle carapace lengths and widths were measured to the nearest tenth of a centimeter. Small skin samples were obtained for future DNA analysis and photographs were taken. In addition, data collectors liaised with fishermen to learn turtle capture location, capture method and use of turtles. In August 2007, five post nesting green turtles from Erikub Atoll had Telonics ST-20 transmitters affixed to their carapaces by members of JIMAR/NOAA PIRO, MIMRA, and WUTMI using fiberglass cloth and surfboard resin. All transmitters sent signals through ARGOS and were processed through NOAA Pacific Islands Fisheries Science Center and data were shared with MIMRA and WUTMI. Turtle Loj 2 traveled to the Philippines and settled into foraging grounds. Another turtle (Loj 1) appeared to forage in Tarawa Atoll, Kiribati, following the track of Jebake of Marshallese legend. One turtle's transmitter ceased transmitting at Bikini Atoll, RMI. Two turtles circled in the open ocean for a few months with one turtle being 100 km South of Pohnpei, Federated States of Micronesia, when the last transmissions were received. The other circling turtle remained within the Marshall Islands EEZ when transmissions ceased. At least two transmitters continued to send location data through September 2008. MIMRA will utilize data from all activities to better inform conservation managers in the Marshall Islands and will exchange information gathered from satellite telemetry with nations sharing the turtle's resources.

## **MEDITERRANEAN MIGRATIONS: ADULT MALE AND FEMALE LOGGERHEAD MOVEMENT BEYOND THE PROTECTED BREEDING AREA OF ZAKYNTHOS**

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The National Marine Park of Zakynthos (NMPZ) protects the marine and terrestrial breeding habitats of the largest breeding population of loggerhead sea turtles (*Caretta caretta*) in the Mediterranean. Breeding areas are primary targets for protection because future populations are also safeguarded by protecting the nests. However, breeding areas represent one segment of an adult's life-history; knowledge about migratory routes and wintering/foraging grounds where turtles spend protracted periods of time is required for effective conservation actions towards protecting reproductively active adults. Preliminary tracking studies indicate that females migrate to grounds in the Adriatic Sea and the Gulf of Gabes, whereas male migration may be more disparate between the Adriatic and Aegean. In 2008, the NMPZ attached 10 Fastloc-GPS transmitters (accurate to within 50 metres) to adult male (3) and female (7 –of which 2 failed) loggerheads at the Zakynthos rookery with the objectives to (i) confirm and improve our understanding of similar nearshore area use by both males and females during the breeding period and (ii) acquire detailed information on pan-Mediterranean migratory and wintering/foraging area movements for both male and female loggerheads. Both males and females were recorded utilising a similar nearshore area in May before males migrated out. All individuals have been tracked to what appear to be stable foraging/wintering areas. One male remained resident, which suggested that some males may not depart the breeding area, hence existing seasonal changes in protection measures may need to be re-addressed. Two males migrated to previously recorded female wintering/foraging areas along the Croatian coastline and in the Gulf of Gabes. The five tracked female turtles also frequented previously recorded foraging/wintering areas. The high resolution datasets could be used to identify and visit specific foraging/wintering areas, in order to characterise in detail those ecosystems in relation to fine-scale habitat use by turtles, as well as the impact of fisheries. This information would contribute to supporting the delineation and implementation of protection zones of the first marine protected areas in the Mediterranean that would protect an important component of the life history of the Zakynthos breeding population across international borders. Ultimately the NMPZ contributes just one component towards effective conservation of the Mediterranean's largest breeding population – due to the turtles migrating to and spending protracted periods of time at disparate foraging/wintering areas – requiring pan-Mediterranean collaborations to protect all aspects of this endangered species life-cycle. Acknowledgements: The presenting author (GS) thanks the National Marine Park of Zakynthos, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, US National Marine Fisheries Service, US Fish and Wildlife Service (Marine Turtle Conservation Fund), the Marisla Foundation and the International Sea Turtle Symposium for travel assistance.

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## **DETECTION OF BEACH-SPECIFIC MAGNETIC SIGNATURES BY SEA TURTLES: THE KEY TO NATAL HOMING?\***

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Loggerhead sea turtles (*Caretta caretta*) from eastern Florida undertake a transoceanic migration in which they gradually circle the North Atlantic Ocean before returning to the North American coast. Later, as adults, the turtles exhibit natal homing on a regional scale, returning to nest in the same general geographic area where they themselves hatched. Young sea turtles are known to use the magnetic fields that exist in different oceanic regions as a system of open-sea navigational markers. In principle, such fields might also function in helping turtles return to nest in the coastal areas where they themselves hatched. As a first step toward investigating this possibility, hatchling turtles were exposed to two different magnetic fields that mark coastal areas in north and south Florida. Hatchlings responded to the field from the northern site by swimming approximately southeast, a response that might serve to help turtles move farther into the Gulf Stream and reduce the chances of being swept into fatally cold water that lies to the north. In

contrast, hatchlings exposed to the field from the southern site, where there is no danger of displacement from the migratory route, were not significantly oriented. The orientation elicited by the two fields was significantly different. Thus, by the time they enter the ocean, hatchling turtles already possess the ability to distinguish among magnetic fields that exist in different nesting areas along the Florida coast. The precision with which turtles can resolve differences among fields is, in principle, sufficient to account for the known resolution of natal homing in Florida loggerheads.

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## RIO DE LA PLATA ESTUARY: A KEY FORAGING AREA FOR LEATHERBACKS IN THE SOUTHWEST ATLANTIC

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Four leatherback turtles (two females, one male and one subadult) incidentally captured in the Rio de la Plata estuary (n = 1) and along the Southwest Atlantic Ocean (SWA) (n = 3) in 2005 and 2006, were tracked from 237 to 630 days using satellite relayed data loggers (SRDLs). Data on vertical habitat utilization was received, including individual dive profiles and summary information on dive duration and maximum depth. A single best location per day was used to calculate the total time (days) spent by the turtles in each cell (0.5°x 0.5°). Also, we identified high use areas for individuals as a criterion to compare the diving behavior observed at those areas. Turtles tended to remain in the western side of the South Atlantic Ocean where specific areas were frequented, and one track documented a round-trip migration between temperate and tropical waters. Previously unidentified high use areas were recognized along continental shelf and break waters of the SWA. Those areas were located both in tropical and temperate regions. The Rio de la Plata estuary and adjacent waters were clearly detected as high use areas as two of the turtles spent 51% (n = 121 days) and 38% (n = 240 days) of their respective total tracking durations there. Additionally, one turtle frequented the area for two years after transmitter deployment, suggesting high site fidelity. It has been noted that this species may undertake annual migrations from temperate foraging grounds to tropical waters, even during non-breeding years. This behavior was observed at least for one of the tracked females as she migrated to tropical waters and approached the nesting beaches in Brazil, where she remained before heading back towards the Rio de la Plata estuary. The adult male also approached the nesting beaches before moving towards the Rio de la Plata, but it is unclear if this behavior represented mating activities. Marked differences on diving behavior between high use areas were noted: individuals in the Rio de la Plata estuary performed shallow and relatively short dives, where at lower latitudes their dives were comparatively longer and deeper, reflecting heterogeneity in habitat and available prey species. Acoustic data and net sample surveys showed that the Rio de la Plata estuary contains high concentrations of *D. coriacea* prey species (scyphozoan medusae) which may explain their prolonged residence in the area. Our results indicate that the Rio de la Plata estuary and outflow waters represent a key foraging area for *D. coriacea* in the SWA and therefore potentially support high densities of foraging leatherbacks as highlighted by a high rate of incidental capture and stranding records of this species in the area. Acknowledgements: Participation at the Symposium was possible thanks to a travel grant by the International Sea Turtle Symposium and the following organizations: Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund).

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## **SATELLITE TELEMETRY STUDIES IN BRAZIL HIGHLIGHT AN IMPORTANT FEEDING GROUND FOR LOGGERHEADS AND HAWKSBILLS: THE CEARÁ STATE COAST**

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Ten loggerheads (*Caretta caretta*) and 15 hawksbills (*Eretmochelys imbricata*) were satellite tracked from their nesting grounds on the northern coast of the State of Bahia, northeastern Brazil. Loggerheads were tracked for 739±194 days (range 426-936 days), during which they migrated to the northern coast of Brazil, moving over the continental shelf along the 100 m isobath. Distance from the coast varied between 3.5 and 170 km. Movements ceased when the turtles arrived at foraging areas spread along a 1,235 km belt located off the States of Ceará (n=8), Maranhão (n=1) and Pará (n=1). The individual foraging areas were clearly delineated, with a core area where animals moved back and forth during inter-seasonal periods. Mean size of individual foraging areas was 8.3±10.9 km<sup>2</sup> (range 1.9–37.9 km<sup>2</sup>), located at a distance (central point) from the coast that ranged from 40-125 km (mean 61.5±23.3 km). Three loggerheads migrated back to their former nesting areas for another reproductive season; time intervals between the end and start dates of these consecutive nesting seasons were 610, 637 and 656 days. These loggerheads returned later to the same foraging areas, moving along the same coastal migratory corridor previously used in both pre- and post-nesting movements. Satellite transmitters from three turtles are still transmitting after almost three years. Three of the 15 transmitters placed on hawksbills stopped transmitting within the first 30 days (two during the internesting period); the remaining 12 were tracked for 486±279 days (range 238-804 days). Five hawksbills moved southward and eight northward. Hawksbills that moved northward stopped at different points, including the States of Bahia (n=1), Alagoas (n=2), Pernambuco (n=1), Rio Grande do Norte (n=1), Ceará (n=1) and Pará (n=2). These animals utilized areas similar to loggerheads', regarding their extension and distance from the coast. Hawksbills that moved southward stopped in different points off southern Bahia (n=4); one moved away from the coast, along the Vitória-Trindade seamount chain before transmissions ceased. Tracked hawksbills were sampled for genetic analysis, and results showed that six were hawksbill-loggerhead hybrids; five of these migrated northward, similarly to loggerheads, and one moved to southern Bahia. Amongst the nine 'true' hawksbills, four moved southward, three northward (to areas different from loggerheads'), and two stopped transmitting before leaving the nesting areas. Northern and southern destinations of post-nesting 'true' hawksbills were characterized by reef ecosystems and differed from those foraging areas frequented by loggerhead and hybrids, which centered their foraging activities on rocky, muddy and sandy marine habitats of Ceará State. Despite the potential effects of hybridization in the post-nesting movements of hawksbills, the key role of the northern Brazilian coast, especially Ceará, and the presence of a coastal migratory corridor for both loggerheads and hawksbills that nest in northeastern Brazil are highlighted by these results which therefore have important conservation implications.

## **MONITORING THE ACOUSTIC ENVIRONMENT OF POST-NESTING LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*)**

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Post-nesting loggerhead sea turtles (*Caretta caretta*) on Casey Key, FL, USA were fitted with bioacoustic tags in the first study of the underwater acoustic environments encountered by turtles after leaving a nesting beach. This technology may prove beneficial in monitoring potential impacts of near shore anthropogenic noise on the natural environment of sea turtles. These tags document natural environmental noise, as well as monitor boat interactions, trawling, dredging events and any other source of noise input to the marine environment. The bioacoustic tags were attached to female turtles after nesting using a fast-drying epoxy. These turtles were also fitted with a satellite-linked PTT and a VHF transmitter for tracking purposes. Bioacoustic tags were set to record on a fixed schedule, either 15 seconds per five minute interval or 5 seconds per 1 minute interval, which was set to maximize battery life. The tag was recovered on the next documented emergence, utilizing satellite and VHF data to locate the turtle. Upon recovery, data was analyzed with a custom MATLAB program designed to calculate sound pressure levels over time. Using this program, it was possible to detect boat noise in addition to surfacing behavior and natural environmental noise. This study provides the first recorded data of the near shore acoustic environment of nesting loggerhead turtles in the inter-nesting interval. This technology is a necessary first step in developing a more complete understanding of effects of seismic exploration for natural gas and petroleum in addition to the responses of turtles to boat traffic. The next generation of acoustic tags has added capabilities to record 3-D acceleration, temperature and depth to record turtle movement in relation to environmental and anthropogenic noise. This study and future studies will create a more thorough understanding of the marine acoustic environment, the presence of anthropogenic noise, and the possible impacts to sea turtles. This research was supported by the Florida Sea Turtle License Plate Grant Program.

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## **REGIONAL MAGNETIC FIELDS AND ORIENTATION BY HATCHLING LOGGERHEADS FROM FLORIDA'S WEST COAST**

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The South Florida subpopulation of loggerheads (*Caretta caretta* L.) consists of a large assemblage of females that nest on the Atlantic coast and a smaller assemblage that nest on the Gulf coast of the peninsula. As such, they provide an opportunity to examine assumed migratory pathways and nursery grounds used by each population and to investigate how natural selection shapes hatchling navigation from natal beaches facing in opposite directions. Hatchlings from nests on the Atlantic Coast have magnetic maps of the North Atlantic gyre and orient appropriately to reach nursery areas on the East side of the Atlantic basin. However, no comparable studies have been done on hatchlings from the Gulf Coast of Florida. It has been assumed that they somehow migrate out of the Gulf of Mexico and into the Atlantic basin, and reach the same Eastern Atlantic nursery areas. We tested this hypothesis by exposing loggerhead hatchlings from Florida's Gulf Coast to four magnetic waypoints within the Gulf of Mexico (Gulf coast waters adjacent to Sarasota, FL; northern extent of the Loop Current south of Pensacola, Florida; western edge of the Loop Current northeast of the Yucatán Peninsula, Mexico; and waters in the central Gulf of Mexico), a waypoint the turtles probably use to migrate between the Gulf of Mexico and the Atlantic Ocean (the Florida Straits), and a waypoint on Florida's Atlantic coast (Melbourne Beach). Hatchlings from the Atlantic coast tested at Melbourne beach orient E to SE, toward the Gulf Stream. If they have similar migratory goals, then hatchlings from the Gulf coast should orient in the same direction. The magnetic field at each waypoint was altered using a large (approx. 2 m) 4-square coil system that duplicated the earth's magnetic intensity and inclination angle at each waypoint location. Gulf coast hatchlings failed to show significant orientation at all of the Gulf of Mexico locations, and at Melbourne Beach. They were significantly oriented to the southwest at the Florida Straits waypoint. That orientation is likely to result in their departure from that

current system and their continued retention within the Gulf of Mexico. Hatchlings are persistent, but weak swimmers; young turtles therefore depend upon oceanic surface currents for long-distance transport. Currents found in the Gulf of Mexico are variable in both position and intensity throughout the year, including the time period when hatchlings are migrating. The lack of strong currents with distinct boundaries could account for the lack of significant orientation in the Gulf of Mexico as there would be no consistent geographic association between a surface current and a magnetic field where orientation could improve survival. The hatchlings also seemed “unfamiliar” with a crucial (Melbourne Beach) Atlantic coast location. Taken together, these results suggest that Gulf coast hatchlings may initially possess regional magnetic maps that differ from those used by hatchlings departing from Atlantic coast beaches, perhaps because they use the Gulf of Mexico as a nursery site.

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## **MOVEMENT PATTERNS OF HAWKSBILL TURTLES ON THE CUBAN SHELF DESCRIBED BY FLIPPER TAGGING AND SATELLITE TRACKING**

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This paper characterizes the migrations of hawksbill turtles (*Eretmochelys imbricata*) on the Cuban shelf. To study the movement patterns of this species in Cuban waters, tag-recapture data from the Cuban National Tagging Program (carried by the Fisheries Research Centre) initiated in 1989 and from other international programs were compiled. Satellite tracking data of hawksbill turtles were also included. Turtles were tagged from four fishing areas along the Cuban shelf, on nesting beaches of Cayos de las Doce Leguas, and from a headstart project. Most of the hawksbill turtles were recaptured within the waters of the Cuban continental shelf in the Cayos de las Doce Leguas, where as many juveniles as adults showed a high degree of fidelity to the tagging location. Only two hawksbill turtles were found on the Nicaraguan coast and one on the Colombian coast. Results of tag-recapture and satellite tracking indicated that on the Cuban shelf, hawksbill turtles move short and long distances, and also remain in the region of the Cayos de las Doce Leguas for a considerable amount of time. Origins of other tagged hawksbill turtles include Mexico, Virgin Islands, Bahamas, Barbados, and Puerto Rico, with the highest proportions coming from Mexico (36.4%) and the Bahamas (27.2%).

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## **PALAU MARINE TURTLE MOVEMENTS: GREEN TURTLE (*CHELONIA MYDAS*) FLIPPER TAG RETURNS AND HAWKSBILL (*ERETMOCHELYS IMBRICATA*) SATELLITE TRACKING**

**Rachael Nash and Joshua Eberdong**

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The Marine Turtle Conservation and Monitoring Program (MTCMP), established in 2004, coordinates marine turtle research and conservation efforts in the Republic of Palau, Micronesia. Two key species of marine turtles found in Micronesia that nest and forage in Palau are green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles. In the past year, more migrations of these turtles to and from the Republic of Palau were documented through titanium flipper tag returns and satellite tracking. Green turtles were found to be highly migratory, but also displayed nest site fidelity. A post-nesting green (R29861) tagged in June 2007 on the remote island of Merir, Sonsorol State, was recaptured in Okinawa, Japan. Another green (R29662) tagged in 2006 after nesting on Helen Island, Hatohobei State, was caught near Goulburn Island, Northern Territory, Australia in March 2008. More green turtles tagged on Helen Island after nesting in 2005 were recaptured when they returned to nest in 2008. A green (R29470), tagged while

foraging near Kayangel State in June 2007, was observed foraging nearby at Ngeruangel Reef 10 months later. A green turtle (RMTP 762) originally tagged on Gielop Island, Yap State, in 1991 was caught near Ngardmau State, Palau, in March 2008 by a local fisherman. These long distance migrations suggest that green turtles in Palau should be considered shared resources. Therefore, both national and international collaboration is necessary for obtaining information regarding their movements and for the preservation of the nesting population in Palau. Satellite telemetry provided insight into the movements and post-nesting behaviors of two hawksbill turtles. More locations of a hawksbill (Diliolomekang), first deployed with an Argos satellite transmitter after nesting in 2006, were received in 2008. A second post-nesting hawksbill (Kmekumereldil) was fitted with a transmitter in June 2008, and her movements were tracked. Transmissions from both hawksbills, though sporadic, showed that they remained close to Palau. If residential, the Palau hawksbill population would be unlikely to be replaced by outside populations. We will discuss how the tag recapture and satellite tracking information is being used in conjunction with nest monitoring results to enhance marine turtle education, strengthen law enforcement and promote pending legislation, as well as its implication for further research and conservation efforts in Palau. These endeavors would not have been possible without the assistance of and collaboration with local community members, state and national organizations and NGOs, and international marine turtle conservationists, demonstrating the importance of increased information sharing.

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## **NESTING BEACH USE PATTERNS OF LEATHERBACK TURTLES (*DERMOCHELYS CORIACEA*) IN BOCAS DEL TORO PROVINCE, PANAMA**

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The province of Bocas del Toro is located in the northwest of Panama, contiguous with the Costa Rican border and the Caribbean Sea. It contains important nesting, migration and foraging habitats used by four species of marine turtles: leatherbacks (*Dermochelys coriacea*), hawksbills (*Eretmochelys imbricata*), greens (*Chelonia mydas*) and loggerheads (*Caretta caretta*). The leatherback is the most common species and the region supports a globally significant leatherback nesting population, with more than 4,000 nests reported each year at Chiriquí Beach. Since 1999, several intensive tagging studies have been conducted at various leatherback nesting beaches in the province: Chiriquí Beach, Long Beach and Soropta Beach. Similar studies were initiated at San San and Sixiola Beaches in 2006. All of these nesting sites are within protected areas, and are subject to varying degrees of protection and conservation by government authorities. The research and monitoring activities are performed by members of local conservation organizations, with the support of international volunteers. Data from these tagging programs suggest that there is significant movement of individuals between the nesting beaches in the region, both within and between nesting seasons. This paper presents a summary of the data regarding the movement of females between nesting beaches as provided by tag encounters recorded by researchers at the different sites in the last eight years. It also discusses levels of individual site fidelity and determines inter-nesting movement patterns around the province. By increasing our awareness of the patterns of nesting beach use by leatherbacks, the results of this study will provide marine turtle researchers and conservation managers with vital information to coordinate and improve the protection of this critically endangered species in Bocas del Toro province.

## **SWIMMING AND DISPERSAL BEHAVIORS OF 1-YEAR-OLD HEADSTARTED LOGGERHEADS IN THE SOUTHEASTERN COAST OF SPAIN**

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Knowledge of the behavior, performance and orientation cues of marine turtles during the first years of their ocean life is sparse. Moreover, the capacity of headstarted turtles to migrate towards and reach the high seas after their release into the ocean is a topic discussed worldwide. The objective of this study was to monitor the early marine migrations of 1 year-old headstarted loggerheads (*Caretta caretta*) and evaluate their performances during the first hours after release near the southwestern coast of Spain. A total of 13 turtles (2007: n=7, weight=500-600g.; 2008: n=6, weight =250-400g.) were tagged with acoustic transmitters and tracked from a boat for up to 4 hours after release. Measures of the superficial current were also taken simultaneously over 10-minute periods for 6 turtle tracks in 2008. Three searches on different dates were performed within one month after release to ensure that no turtles returned to the release area or remained in the nearby coastal areas. Turtles initiated their migrations immediately in a 30-150 degree angle to the coastline. Movement rates averaged 1.44 km/h in 2007 and 1.04 km/h in 2008. None of the monitored turtles returned to the release area. Tracks averaged 3.7 km and were 2.2 km away from the coastline in both years. Smaller turtles swam slower and a shorter distance than larger turtles, indicating that size may also be related to migration speed. The observed direction of movement depended on the turtle and not on the water current. The turtles moved in all compass directions, with the lowest frequency towards the coastline, resulting in a net movement towards deeper areas. The movement patterns resemble those observed from recovered wild turtles.

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## **EASTERN AUSTRALIAN MARINE TURTLE SATELLITE TRACKING PROJECT – FOLLOWING INSHORE AND PELAGIC FORAGING SUB-ADULTS**

**Carolyn Robins and David Kreutz**

Belldi Consultancy, Australia

We satellite tracked foraging sub-adult marine turtles in Eastern Australia: four oceanic pelagic foragers and five new recruits into inshore foraging grounds in Moreton Bay, Brisbane. The objective for the oceanic turtles was to describe movement patterns of a virtually unknown stage of their lives, and for the inshore turtles to gather new information concerning turtles foraging in legislated vessel 'Go Slow Zones'. The pelagic foragers, Andy (51 cm female olive ridley), Jack (42 cm green), Azriel (75 cm loggerhead) and Holly (50 cm green), were captured by longline vessels, satellite tagged with Sirtrack tags by fisheries observers and released. These turtles moved in surprising ways, at amazing speeds and didn't behave as other tagged turtles have in other parts of the world. Additionally, they transversed the boundaries between Australia and international waters a number of times which confirms that many nations must work together to ensure these oceanic wanderers continue to survive. The inshore foragers, Harry (82cm female loggerhead), Fly (38 cm female hawksbill), Neil (female green), Samie (66 cm female green) and Trevor (73 cm female loggerhead), demonstrated the importance of fishing and recreational vessels in Moreton Bay to not only respect the 'Go Slow Zones' but to also be aware that turtles don't know where these zones start and stop.

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## NO TIME TO CHILL OUT: GPS TRACKING REVEALS MICRO-HABITAT SELECTION BY BREEDING LOGGERHEAD TURTLES\*

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Loggerhead turtle (*Caretta caretta*) breeding areas are distributed across subtropical and temperate latitudes. The rookery on Zakynthos Island in Laganas Bay is unusual in that it is relatively large despite being situated at the latitudinal margins of the species' breeding range. When turtles migrate to Zakynthos to mate in March–May, sea surface temperatures are generally cool (c.13–22°C) before increasing towards mid-summer. Turtles may display thermal selection to overcome cold conditions, although such thermal selection has not been demonstrated before in sea turtles. We examined turtle activity on Zakynthos to see if there was evidence of thermal selection, and considered the possible benefits for enhancing reproductive fitness. Ad-hoc surveys at sea conducted between April and July in 2003–2005 indicated that female turtles tended to aggregate along a 5-km section of coastline within the bay, so we focused our research in this area. In 2006, morning and afternoon transect surveys (along five transect lines) were conducted to obtain information on sea-surface and seabed temperature at 15 stations (using Tinytag loggers), and sea turtle distribution. Weather data were recorded at two land-based stations. Navsys Ltd TrackTag GPS-loggers and LOTEK Ltd 1100 time-depth recorders (TDRs) were attached to three female loggerheads for 17, 31 and 25 days between 20/05/2006–23/06/2006. We also attached TDRs to three other females for 31, 12, and 21 days between 16/05/2006–27/06/2006. We found strong correlations for wind direction with both sea-temperature and turtle distribution. These observations were supported by the GPS-tracked turtles, with 65% of variation in daily mean position explained by wind direction. Analysis of individual GPS-tracks showed that turtles were not simply located downwind (i.e. passive advection), but rather travelled parallel to the shore by moving across the wind direction (i.e. active selection). The temperature loggers suggested that temperatures at depths further from shore were >2°C cooler than shallower temperatures, implying the actual water temperatures in late May were probably >5°C above those they would have experienced if they rested at >10 m. We used the empirical relationship between interneeting intervals and water temperature to estimate that by selecting warm water, the first clutch might be deposited as much as 5-days earlier. Loggerheads will therefore maximize the number of clutches they lay within a season that experiences optimum development temperatures even close to hatching. Furthermore, reducing the time required to lay the first clutch means that turtles are able to minimize time away from foraging grounds. In summary, we have shown how female loggerheads, near the limits of their breeding range, reposition themselves daily to take advantage of thermal hotspots within a highly dynamic thermal environment. How turtles achieve this selection is unknown, but it probably contributes to the success of this species near its cold water range limits. Acknowledgements: I thank the National Marine Park of Zakynthos, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), the Marisla Foundation and the ISTS for travel assistance.

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## EXAMINATION OF SATELLITE TRANSMITTER ATTACHMENT TECHNIQUES FOR JUVENILE SEA TURTLES

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Five immature and three adult female Kemp's ridleys (*Lepidochelys kempii*) were tracked for considerably shorter periods than expected (mean=38 days, SD=15) after platform terminal transmitters (PTTs) were attached with PowerFast epoxy in 2004-2005. Integration of antifouling paints and a second adhesive, Sonic-Weld epoxy putty, increased track duration for adults but not juveniles in 2006. This discrepancy suggested high juvenile growth rates may precipitate premature transmitter loss and prompted development of less-rigid attachment methods. Trials comparing PowerFast-only (PF-only), PowerFast/Sonic-Weld (PF/SW), and two experimental neoprene attachment methods were conducted February-June 2007 and July 2007-February 2008. Sixteen 30-month and eight 23-month-old, captive-reared loggerheads (*Caretta caretta*) were randomly distributed among four attachment types in each trial. PF-only and PF/SW protocols matched those used previously with two exceptions: (1) transmitter bases and turtle carapaces were sanded with coarser (60-grit) sandpaper and (2) initial "squeezes" of PowerFast were discarded to ensure proper curing. Pieces of 1.5-mm and 3.0-mm neoprene were cut 3-4 cm larger than a PTT base for the experimental methods. Scutes within each attachment site were outlined with RTV silicone to provide a barrier to epoxy. PowerFast was applied at the attachment site avoiding the silicone, neoprene placed atop the epoxy, and a PTT then adhered to the neoprene. Loggerheads were maintained under NOAA husbandry protocols, and those in the second trial were fed to achieve higher growth rates. Attachment integrity was checked manually each week, and turtles were monitored for PTT loss throughout each trial. Carapace measurements were taken monthly and when PTTs were shed. Average daily growth was estimated using linear regression. All PTTs remained attached in the first trial, despite an overall loggerhead growth rate of 0.024 cm/day and average SCL increase of 3.4 cm (SD=0.4 cm) in 132 days. This result suggested better attachment site preparation and/or discarding potentially unmixed PowerFast improved upon previous PF-only and PF/SW methods. Loggerheads grew at a higher rate (0.045 cm/day) in the second, 213-day trial, and two PTTs were shed. PowerFast sections on the perimeter of one 3.0-mm neoprene attachment were unattached on Day 81, and the PTT fell off 3 days later (+3.7 cm SCL). Likewise, gaps were noticed along the perimeter of one PF-only attachment on Day 105, and this unit came off on Day 127 (+5.4 cm SCL). Six other PTTs sustained average SCL growth of 9.6 cm (SD=0.3). Substantial gaps occurred along the perimeter of the remaining non-neoprene attachments, and two neoprene attachments became loose along the edges but remained secure in the center. In all likelihood, the three remaining non-neoprene attachments would have been shed much sooner in a natural environment, where turtles often rub on and/or sleep under hard substrates. This may have also been the case for the neoprene attachments, but the trials suggested that carefully applied neoprene attachments may be beneficial for tracking smaller, faster-growing sea turtles. Further assessments should utilize turtles exhibiting high growth rates and examine the effectiveness of neoprene and non-neoprene attachments subjected to more natural turtle behavior.

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## **FINE SCALE MOVEMENT AND ACTIVITY PATTERNS OF EAST PACIFIC GREEN TURTLES AT A COASTAL FORAGING AREA IN BAJA CALIFORNIA SUR, MEXICO**

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The east Pacific green turtle (*Chelonia mydas*), known locally as the black turtle, is currently listed as endangered. Green turtles, like most sea turtle species, utilize several different habitats within their lifetime. One of the most important habitats for green turtles are neritic foraging areas where these consumers feed and grow until reaching maturity. Although recent studies have provided a framework for the spatial ecology of green turtles on their foraging areas, little fine scale data is available. Therefore, we examined the fine scale movement and activity patterns of green turtles in San Ignacio Lagoon, a coastal foraging area off the Pacific coast of Baja California Sur, Mexico. Here we present results from seven turtles, ranging from 44.6 to 83.5 cm SCL (straight carapace length) that were tracked with radio and GPS telemetry for 48-72 hr periods. Our data indicate that green turtles may travel large distances and visit multiple habitats over relatively small temporal durations. Based on the diversity of movements and habitat use of green turtles tracked during this study, management efforts aimed at protecting these marine megaherbivores may need to include the entire coastal ecosystem, rather than a few critical areas in San Ignacio Lagoon.

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## **SATELLITE TRACKING REVEALS HIGH-USE HABITATS AND 3D THERMAL ENVIRONMENT FOR INTERNESTING EASTERN PACIFIC LEATHERBACK TURTLES AT PLAYA GRANDE, COSTA RICA\***

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Satellite tagging studies involving 46 nesting females tagged at Playa Grande, Costa Rica during 2004 (n=27), 2005 (n=8), and 2007 (n=11) revealed that although internesting females demonstrate exceptional nesting fidelity to their natal beach, they disperse widely along Costa Rica's Nicoya Peninsula during internesting intervals. Analysis of internesting tracking data has revealed important high-use habitats in the Gulf of Papagayo and along the Santa Elena Peninsula. Analysis of satellite sea surface temperature (SST) imagery suggested that interannual differences in turtle internesting movements were influenced by SST. During the 2004 internesting intervals, Papagayo upwelling disrupted the northward Costa Rica Coastal Current (CRCC), separating cooler habitats north of the nesting beach from warmer CRCC-influenced regions along the Nicoya Peninsula and southern internesting habitats. The 2005 nesting season was the coolest internesting period of our study, and was influenced by strong Papagayo upwelling and a weak CRCC. The warmest year of the study was 2007, which was characterized by a weak Papagayo upwelling and a strong CRCC.

Turtles moved into the Gulf of Papagayo and remained in the lee of the CRCC during years when the CRCC was strong. Initial post-nesting turtle trajectories suggest that the CRCC may influence turtle migration and ultimately movements to foraging habitats in the South Pacific Gyre. During the internesting period, turtles are concentrated in time and space, and thus vulnerable to fishing effort and other human pressures. These data support the need for enhanced protection of interesting habitats and development of adaptive management strategies that respond to real-time environmental variation to protect interesting turtles.

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## **SURFACING BEHAVIOR OF LOGGERHEAD TURTLES IN THE INTERNESTING PERIOD: INSIGHTS FROM ANIMAL BORNE IMAGING SYSTEMS**

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Vessel traffic has become an identified hazard to sea turtles, particularly for seasonal migrations of females that swim within nearshore zones during the internesting intervals between multiple nesting attempts. We used animal borne imaging systems (Cittercams) for an initial evaluation of hazards within the first 24 hours after female loggerhead turtles departed a nesting beach to determine whether the characteristic surfacing behaviors of female loggerhead turtles placed them at risk from boat strikes within this period. We recorded stereotypic patterns of swimming and surface events, including periods of bottom, midwater, and surface zone swimming, steep descents but slow ascents between these zones, and occasional prolonged bouts of bottom inactivity and short durations of surface inactivity. Activity levels differed by habitat type, including affinities for bottom structure or live bottom for possible refugia during ovulation, whereas the sparse sandy bottoms were usually traversed. Mean surface intervals and periods of transit within a meter of the surface occupied from 14 to 35% of the dive profiles. The extent of surface behavior may place them at spatial and temporal risk zones for vessel-related mortality.

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## **COMBINING OCEAN CURRENT MODELS AND TURTLE STRANDINGS DATA TO DETERMINE THE AT-SEA DISTRIBUTION OF LOGGERHEAD TURTLES\***

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Understanding the at-sea distribution of loggerhead turtles is critical for predicting the sources of mortality affecting these animals and for identifying management actions that might be taken to ameliorate those threats. For instance, although it is well known that pelagic fisheries affect these animals, it is difficult to identify potential areas for fisheries closures without data on the at-sea distributions of the animals. Traditional sources for these data, such as electronic tagging and interaction data from fisheries observers, can be difficult to obtain. For instance, fisheries observers are only present on 5% of Australia's tuna fishing vessels, and given relatively low interaction rates, making spatial predictions from these sparse data is challenging. In contrast, strandings data can be quite extensive, covering large temporal and spatial scales, and are relatively low cost to collect. We utilize an ocean current model developed by CSIRO to predict the potential source location of loggerhead turtles that were found on beaches along the east coast of Australia. Combining estimates from an extensive strandings database covering the entire east coast of Australia, we make inverse predictions of the at-sea distribution of the turtles. We also explore the potential bias in the estimates of the at-sea distribution, by assuming smooth functions for distribution and then correcting our estimated distribution for turtles that would not be expected to wash up on Australian beaches.

## **SOCIAL, ECONOMICAL, CULTURAL AND LEGAL**

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### **UPDATE ON THE COMMUNITY NETWORK FOR THE RECOVERY OF THE LEATHERBACK TURTLE IN MEXICO: WORKING TOGETHER FOR A COMMON CAUSE**

**Ana Rebeca Barragan and Laura Sarti**

Dirección de Especies Prioritarias, CONANP, Mexico

The leatherback turtle (*Dermochelys coriacea*), the largest of all sea turtle species, is a Critically Endangered species according to IUCN. In Mexico, it is considered as Endangered by Mexican laws and regulations, a category that designates the most critical condition (NOM-059-ECOL-2001). The number of female leatherbacks nesting on the Pacific beaches of Mexico declined more than tenfold in less than a decade. Protection activities were implemented for the first time in 1982, in order to improve the recruitment of hatchlings to the wild population. In 1995, several institutions working in the conservation of the leatherback in Mexico gathered to form Proyecto Laúd (Leatherback Project), which is currently coordinated by Dirección de Especies Prioritarias para la Conservación - CONANP. In 2004 the Community Network for the Recovery of the Leatherback Turtle was formed as part of a strategy to conserve the species. This Network links coastal communities that inhabit the priority conservation areas for leatherback turtles with the authorities of the States that host the most important nesting areas and the federal government, as well as to promote the exchange of experience and information, and increase their awareness on the plight of leatherback turtles. After six meetings, the Network participants show an amazing understanding of the critical aspects of the leatherbacks's lifecycle, and have provided valuable input for the National Action Program for the Conservation of the Leatherback in Mexico. This presentation shows their contributions and the Network's progress.

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### **DEFINING KEY BIODIVERSITY AREAS IN MELANESIA FOR MARINE TURTLES**

**Deborah Bass<sup>1</sup> and Paul Anderson<sup>2</sup>**

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<sup>2</sup> Pacific Regional Environment Programme

Conservation International uses the Key Biodiversity Area (KBA) approach to define sites of global significance for biodiversity conservation. Sites are identified using globally standard criteria and thresholds that are needed to maintain biodiversity at the site scale. The criteria are based on the two main principles of systematic conservation planning, irreplaceability of site and vulnerability of species and site. An irreplaceable site is unique in that it holds a significant proportion of the global population of a species. Vulnerability is the level of threat to a site, or a species that the biodiversity value will be lost, ie the presence of a Critically Endangered or Endangered species, or >30 individuals of a Vulnerable species (IUCN criteria). The KBA approach was developed from quantitative criteria pioneered by Birdlife International for designation of Important Bird Areas and extended successfully to terrestrial and freshwater species by Conservation International. The KBA criteria developed for terrestrial systems need modification to apply to the marine system, due to the greater connectivity, faster turnover rates and 3-dimensional nature of marine systems. This is further complicated by the scarcity of data available on distribution, population and threats to marine taxa. Hence, provisional criteria and thresholds have been adapted for marine KBAs, but these require testing before being standardised. Not all marine species will be suitable for KBA selection because of their wide ranging nature. The species most likely to benefit from site-scaled conservation are those that regularly occur at a site. The seasonal nesting aggregations of globally threatened Sea Turtles are obvious candidates for site conservation. The poster presents KBA definition for 5 threatened species of Sea Turtle in the Western Pacific region (Melanesia) as a case study in developing standard criteria and thresholds for defining marine KBAs. A KBA network defined according to the presence of

species meeting the irreplaceability or vulnerability criteria should include all sites that play a crucial role in maintaining the global population of species. The development of KBA networks for a species is a data-driven process, using the best available data, however it is recognised that there are gaps and biases in datasets depending on where surveys have been conducted. The next phase of the KBA process is to review these KBAs for any known gaps of occurrence and refine boundaries. This poster presents KBAs for turtle for the Western Pacific region based on available current data, and outlines the decision process used. This presentation will launch the review process and the maps will be circulated to turtle researchers for review.

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## **THE TURTLE VILLAGE TRUST, TRINIDAD AND TOBAGO, WEST INDIES: CONSERVATION AND MANAGEMENT OF SEA TURTLES THROUGH COMMUNITY COLLABORATION AND SUSTAINABLE DEVELOPMENT**

**Michelle Cazabon and Allan Bachan**

Turtle Village Trust, Trinidad and Tobago W.I.

The islands of Trinidad and Tobago support more than 80% of all leatherback sea turtle (*Dermochelys coriacea*) nesting in the insular Caribbean Sea and the nesting beaches of the north and east coasts of Trinidad support the 2nd largest nesting colony in the world with an estimated 6,000 leatherbacks nesting annually. Given the extensive range of the leatherback, and Trinidad and Tobago's unique role in providing some of the most important nesting habitats for the species in the Atlantic Ocean, the fate of this Critically Endangered species in the Atlantic, is heavily influenced by management of the nesting turtles on Trinidad and Tobago. Management of this vital nesting colony is the responsibility of the Government of Trinidad and Tobago's Department of Forestry Wildlife Section. Active management of the colony began in the late 1980's and early 1990's with efforts to stop rampant killing of adult females on the nesting beaches for sport and meat. In response to limited financial and personnel resources, the Wildlife Section initiated the formation of local non-governmental conservation groups, and established co-management of the nesting beaches with those local NGO's. Beach patrols have significantly reduced the level of poaching at these beaches, and also allow for tagging of nesting turtles, collection of morphometric information, documentation of mortality sources, assessment of population trends and behavioural patterns, supervision of eco-tourism, and education of the public. Four active local turtle conservation groups first came together because of the common challenges they experienced in the conservation of sea turtles. These difficulties are access to funding, lack of trained staff, standardizing and nationalizing conservation protocol, and building strong organisational infrastructure. The communities approached BHP Billiton Trinidad & Tobago to support a national conservation programme and it is from this interaction that the company inspired the groups to think bigger. This level of collaboration gave birth to the "Turtle Village Trust". The Turtle Village Trust is focussed on capacity building, public awareness and education, conservation, research and monitoring and sustainable community development.

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## **ECONOMIC, SOCIAL, ENVIRONMENTAL, AND CULTURAL IMPACTS OF ACTIVITIES CENTERED AROUND SEA-TURTLES AT REUNION ISLAND**

**Stéphane Ciccione<sup>1</sup>, Claire Jean<sup>1</sup>, and Jérôme Bourjea<sup>2</sup>**

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In 1977, the creation of the sea-turtle ranch "Corail" in St Leu (Reunion Island – France DOM) was presented as an opportunity to reduce unemployment and increase the export of goods for a French territory with a high unemployment rate (40% of the work force) and an adverse trade balance. Twenty years later, the ranch was closed due to changes in international and national legislation. The Regional Council decided to transform the former farm into a 'site of excellence', with emphasis on marine turtle research and public education. Exhibitions displayed at the new centre "Kélonia" have been designed to illustrate the importance of sustainable resource utilisation, especially in the context of marine environments. The purpose is to encourage visitors to reflect on the necessity and the difficulty of

considering economic, societal, environmental, and cultural factors in any decision making process. It is for this reason that great emphasis is placed on social science, as well as natural science. This allows to illustrate both the exceptional biology of marine turtles and the numerous and interesting bonds that tie them to human cultures. Our study focuses on the changes of indicators that were used to evaluate the impact of “Sea-turtle activities” on the community of Reunion Island between 1960 and 2008: - Sales turnover at Corail and Kelonia; - Jobs created by Corail and Kelonia; - Sea turtle population (nesting activity and aerial surveys) and protected habitats; - Visitors of Corail and Kelonia; - News coverage of sea-turtles in the local press. Whenever possible these local data are compared with data on an island wide scale: - Economic activity at Reunion Island; - Work force at Reunion Island and rate of unemployment; - Demographic development (Number of inhabitants and tourists); - Media development (number of daily newspapers and television channels).

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## **REDUCING MORTALITY ON NESTING BEACHES IN CABO VERDE THROUGH STRUCTURED COLLABORATION WITH GOVERNMENT AND COMMUNITY**

**Jacque Cozens**

SOS Tartarugas Cabo Verde, Santa Maria, Sal Island, Cape Verde

SOS Tartarugas began working in June 2008 to stop the poaching of turtles, which previously resulted in 100% mortality on some beaches. This objective was achieved within just 3 months, with only 1 death (out of 46 emergencies) that occurred on protected beaches compared to 1 in 6 on non-protected beaches. This has been accomplished through the careful collaboration between this new NGO, governmental and law enforcement agencies, businesses, tourists and communities. We work in partnership with the DGA (Dept of Environment), the Câmara Municipal (local government), Maritime and Civil Police, INDP (Fisheries) and ISECMAR (Marine Sciences Institute). The project is incorporated into the National Plan for the Protection of Marine Turtles. Other threats to the turtles include nest destruction by vehicles, egg poaching and the collection of turtles (in tourist facilities and homes as pets), loss of habitat (plastic waste and depleted beaches) and massive shoreline development. Public awareness of conservation issues has been very low. The strategy has been to train Capeverdean Wildlife Rangers, who with overseas and local community volunteers patrol the beaches every night and morning. Former turtle keepers have also been recruited. Rangers have saved 18 turtles that were about to be killed and, together with the Public Prosecutor, we are bringing the first action against hunters for Environmental Crime. The only turtles lost on protected beaches have been killed far from the beach, something that was previously unnecessary, as killing turtles was considered risk free. Protected areas (including a hatchery) have been established (first official quad/ATV trails in Cabo Verde) as well as an ecotourism programme, a ‘turtle friendly’ programme for businesses and beach clean ups. All illegal tourist attractions with turtles have been closed down. The high profile educational and outreach campaign addresses many cultural themes and is incorporated into regular television and radio programmes, public film-shows, captive turtle releases, school visits, information boards and turtle awareness workshops for the military, fishermen, police and other groups. SOS Tartarugas has been an enabling factor in enforcing existing protection laws and strong relationships have been established with military personnel (soldiers patrolling beaches), civil police (direct radio link), maritime police (exclusion zones on beaches), port authority and INDP (work with fishermen), the DGA and the Câmara Municipal with whom we work on a daily basis. Many residents support our activities and the potential for income generated from live turtles has been clearly demonstrated. The governmental and law enforcement departments benefit through the lack of bureaucracy and the dynamic approach of the NGO which enabled the campaign to start very quickly. In addition, we were able to fundraise and remove obstacles that had previously hampered them. The NGO benefits from the support and collaboration of each department and the keys to this success have been the careful nurturing of each relationship, the delivery of all promised programmes, the consistent approach and the high level of awareness-building activity within the community.

## **TURTLE CONSERVATION IN NEW-CALEDONIA**

**Jean-Louis D'Auzon**

Association pour la Sauvegarde de la Nature Neo-Caledonienne, Nouméa, New-Caledonia

“L’Association pour la Sauvegarde de la Nature Neo-Caledonienne” (Association for the protection of New-Caledonia’s Nature = ASNNC) was created on May 6, 1971. Its conservation activities expanded to include marine turtles in 1984. The Association’s impact has motivated legislation in July 1985 which prohibited turtle capture during the nesting season (November 1-March 31). Except for special occasions, turtle harvesting has been banned since June 13, 2006 in Province Sud and since September 1, 2006 in Province Nord. From 1989 to 2004, ASNNC organised annual missions to d’Entrecasteaux Reefs to count and tag green turtles (>4,000 turtles processed). The study included a 3 month continuous stay at Huon Island during Oct 2003–Jan 2004. Tagged females have migrated to forage throughout New Caledonia, eastern Australia and PNG. ASNNC’s collaboration with Queensland Turtle Research and the local volunteers, “Bwara Tortues marines”, initiated the monitoring of the principal loggerhead rookery at “La Roche percee”, Bourail for three summers 2005-2008. Since 1984, ASNNC has maintained a major turtle awareness campaign with news articles, radio and TV shows, movies, games and information sheets. On April 21, 2004, a juvenile loggerhead turtle from Noumea’s Aquarium was released and satellite tracked via Argos until December 2004. The public followed her journey on the internet.

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## **THE OLIVE RIDLEY GOES BEYOND A FLAGSHIP SPECIES USED TO DERIVE SOCIAL AND ENVIRONMENTAL CHANGE IN CHENNAI**

**Supraja Dharini**

Tree Foundation, Trust for Environment Education, Study of Marine Mammals and Community Development, Chennai, India

This poster illustrates our conservation efforts for olive ridley sea turtles by involving the community of fishermen that dwell on the coastal fishing villages in Chennai, India. The coast of Chennai is the nesting site of the endangered olive ridley sea turtles. The nesting beaches of the fishing villages, i.e. Periya Neelangarai, Injambakkam, Panaiyur, Nainarkuppam (Uthandi) and Reddy Kuppam – Kanathur, are patrolled by the youth of the fishing communities. They were recruited by the Tree Foundation in 2002 to protect and relocate the eggs and to release all hatchlings into the sea on a volunteer basis. These volunteers are known as the “Kadal Aami Padhukavalrgal” (Sea Turtle Protection Force). This initiation of community conservation of the olive ridley sea turtles has successfully progressed in the last six years. This poster also describes the methods for outreach programs used for the fishing communities, schools, college students and general public to spread the awareness of the roles of sea turtles as flagships in the coastal biodiversity. International Coastal Cleanup Day, Flipper Fest – A Marine biodiversity Conservation, Awareness Mela (Annual event), turtle walks and many more programs use the sea turtle conservation program as a foundation to make people more environmentally aware and to become ambassadors for the ocean. The main programs conducted for educating the fishing community are: one day environmental education workshops for the youth and children at zoos, sanctuaries, etc., slide shows, sand modeling competitions, street plays, puppet shows, peace rallies, the Pungamiya Plantation for Biodiesel project, youth workshops for men to form self-help groups, temperature maintenance in hatchery management and sea turtle awareness programs for the trawl boat and mechanized fishing community.

## **EDUCATIONAL PROGRAM OF PROYECTO PEYU-PRICTMA**

**Jose Luis Di Paola and Cintia Echenique**

Peyu Project, Sea Turtles of Argentina, PRICTMA, La Plata, Buenos Aires, Argentina

For seven years our conservation and research project has coordinated an educational program to increase awareness of the three species of sea turtles found in Argentina: *Caretta caretta*, *Chelonia mydas* and *Dermochelys coriacea*. Initially, we noticed a lack of community interest toward these species, presumably due to the lack of understanding about their presence offshore and on the beaches of Argentina, as well as about the threats to sea turtles. Confronted with these two challenges, we started an educational program that would involve a collaboration of people with diverse backgrounds, including biologists, teachers and designers, who would participate in the program's planning and implementation. As a result of this program, a significant portion of the community is now familiar with sea turtles and their presence in Argentina and in the world. They also understand that the country has important developmental, feeding and migration areas for many sea turtle species. The program was provided to people through scientific publications, brochures, and children's books. We also presented papers at conferences, and organized training courses and workshops to establish the sea turtle as a symbol for animal protection. It is especially important for coastal communities and fishermen to play a role in sea turtle protection, because their actions have a strong impact on sea turtles. At the same time, the non-coastal population can also collaborate in conservation efforts by informing the research centre or by raising awareness. We expect to continue our work, focusing more in the Buenos Aires Province and the south of the country where reports of sea turtles are increasing.

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## **SHARING DEVELOPING COUNTRY EXPERIENCE-AN INSIDE LOOK AT THE STRUGGLES IN SEA TURTLE RESEARCH AND CONSERVATION IN VENEZUELA \***

**Emma Doyle<sup>1</sup>, Joaquín Buitrago<sup>2</sup>, and Hedely J. Guada<sup>1,3</sup>**

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<sup>3</sup> WIDECAST

This presentation addresses the need to build communication networks among sea turtle researchers and conservationists working in developing countries. It takes an insider's perspective on the challenges that face sea turtle research and conservation in Venezuela and reviews experience since the first concerns about the status of the country's sea turtle populations arose in the 1970s. Although the development of sea turtle research and the pathways towards sea turtle conservation differ around the globe, developing countries face some common challenges. The evaluation of Venezuela's programs reveals much about the realities facing conservation scientists in developing countries and about the forces that can shape and potentially derail research and conservation efforts. Venezuela's earliest projects from the 1970s were a tagging program for green turtles at Aves Island and a nesting beach evaluation and in situ nest protection in the Los Roques Archipelago. Since then, efforts to develop sea turtle research and to implement conservation measures have resulted in a number of hits and a score of misses. Among the achievements is the training course "Sea Turtle Biology and Conservation Techniques" which has now been offered for 15 years, has educated several hundred participants and enabled the establishment of a valuable professional network extending beyond the country's shores. But Venezuela shares with other developing countries some crucial shortcomings which have restricted the success of conservation and research efforts. While regulations relating to protected areas and natural resource use have proliferated, enforcement is weak. Community-based projects and environmental education programs exist, but levels of participation are low. A large number of conservation approaches have been applied, including head-starting and nest translocation to hatcheries, but their value as conservation tools remains unproven. Research has increased, but its impact on decision-making is not significant. Through a review of national scientific literature spanning some 35 years, together with the reflections of some key players in academia, field research and

conservation grant-making, we evaluate the lessons learned in Venezuela and share our experiences with others working in developing countries.

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## **REDEFINING SEA TURTLE STRANDING RESPONSE IN URUGUAY: CAPACITY BUILDING, AWARENESS CAMPAIGNS, COMMUNICATION AND NETWORKING – SOME NEW DIRECTIONS AND NOVEL APPROACHES**

**Andrés Estrades<sup>1</sup>, Alejandro Fallabrino<sup>2</sup>, Virginia Ferrando<sup>2</sup>, Anand Ramanathan<sup>3</sup>, and Eduardo Santurtun<sup>4</sup>**

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<sup>4</sup> International Fund for Animal Welfare, Mexico City,

Five of the seven species of the world's sea turtles are present in Uruguay. Most commonly, Green (*Chelonia mydas*), Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) turtles inhabit the Uruguayan waters while sporadic observations of Hawksbill (*Eretmochelys imbricata*) and Olive Ridleys (*Lepidochelys olivacea*) have also been recorded. Populations of green, loggerhead and leatherback turtles face many threats such as incidental capture in fisheries, capture for illegal carapace trade, marine pollution, infection and pathologies, and a lack of popular knowledge regarding their presence in these waters. Some of these threats directly lead to their stranding along the entire eastern Uruguayan seaboard. Responding to mitigating these threats and to save the stranded turtles has been a major focus of Karumbé since 2001 through their stranding and salvage network which receives over one hundred calls about stranded turtles each year. Over the years, we have added another dimension to the strandings response by building a partnership with IFAW for rehabilitation of stranded turtles. Training wildlife rangers, coastguard personnel and beach lifeguards about sea turtles' biology and first aid will be a new addition to existing efforts. Emergency hotlines and increased veterinary and rehabilitation infrastructure are to complete the picture with regard to the new developments. These efforts have been further complemented by public awareness programs designed to educate the target audiences about the status of sea turtles and the opportunities to reduce human-induced threats to turtles. In order to involve the network's members and new key actors in beach surveys and stranded turtle rescue, an awareness campaign "They are in trouble, you are the solution" powered by communication tools, is to be launched. We consider that the release events are an important tool to raise awareness and engage the society on the sea turtle conservation. For this reason, we invite local communities and mass media to be part of the release events. Through this presentation, we attempt to describe our new direction and novel approaches that have shown promise in engaging target audiences through public communication while simultaneously increasing our capacity to save stranded sea turtles.

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## **MARINE TURTLE RESEARCH AND CONSERVATION IN SOYO, NORTHERN ANGOLA**

**Betania Ferreira<sup>1</sup>, Angela Formia<sup>1</sup>, Antonio Nogueira<sup>1</sup>, Warren Klein<sup>2</sup>, Tim Bayhnam<sup>2</sup>, and Howard Rosenbaum<sup>1</sup>**

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The Wildlife Conservation Society (WCS) has joined Angola LNG (Angola Liquefied Natural Gas, AngLNG) in a partnership aimed at research and conservation of marine turtles in the Soyo region of northern Angola. The Sereia Turtle Project covers 15 Km of beach, along the western coast of Soyo, Sereia Peninsula (Atlantic Ocean), and AngLNG covers 5 Km of beach at Kwanda Base, along the northern coast of Soyo (Congo River). Data has been collected since 2006 at Kwanda Base and since 2007 in the Sereia Peninsula. Though data collection is ongoing and

data collected to date is relatively limited, it is sufficient to establish the importance of the region as significant olive ridley nesting habitat. In addition, evidence indicates the presence of feeding and/or developmental grounds for green turtles. Nesting leatherbacks observed here in the past could not be confirmed in the last season. Regular daily monitoring and data collection of nesting beaches, were conducted for the protection and management of nests, hatchlings and nesting females. Tagging and biometric data of all sighted individuals were also collected. All nests were identified and their position recorded; threatened nests are relocated in situ or to a protected hatchery. Currently, the sea turtles in the Sereia Peninsula are subject to heavy exploitation for their meat and eggs as a source of protein and income for coastal villagers. At Kwanda Base turtle habitat is threatened by dredging, construction and land-reclamation. The biggest challenge that the project now faces is to decrease the levels of predation, attempt to mitigate human-induced threats, and increase hatching success for both relocated and wild nests. In the Sereia Peninsula, a program was developed to convert turtle poachers and fishermen into turtle patrollers and monitors. Environmental education activities were carried out throughout the region, including seminars, workshops, informal discussions and exhibitions. In addition, potential alternative sustainable sources of income in the villages within the project area are being explored to generate direct and indirect benefits for the local communities. The relationships established with the local communities allowed the effective protection of sea turtles and their nests. Indeed, though there is scope for continued work, Projecto Sereia has already achieved one of its primary goals: modifying attitudes and opinions in the region that “a live turtle is more valuable than a dead one.”

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## **ESTABLISHING A SOCIO-ECONOMIC BASELINE OF SEA TURTLE CONSERVATION TOURISM IN BAJA CALIFORNIA SUR, MEXICO\***

**Elena Finkbeiner<sup>1</sup>, Brad Nahill<sup>2</sup>, Larry Crowder<sup>1</sup>, and Wallace J. Nichols<sup>3</sup>**

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Baja California Sur, Mexico provides vital habitat to five of the seven extant species of sea turtles, all of which are listed as endangered or threatened under the International Union for Conservation of Nature's (IUCN) Red List. Sea turtles are threatened in the region from illegal meat and egg hunting and collecting, and incidental capture in artisanal and commercial fishing gear. The birth of a progressive community-based environmental management movement in northwest Mexico, led by the Mexican organization Grupo Totuguero, has provided a powerful opportunity to conceive and develop conservation tourism projects in the area, as locals may be able to utilize their natural resources in a non-consumptive, sustainable manner to their socio-economic benefit. A conservation tourism project, SEEturtles.org, has recently partnered with local Baja tour operators (Journey Mexico and Baja Expeditions) and NGOs (Grupo Tortuguero and ProPeninsula) to advance conservation in the region. However, conservation tourism is a complex and multi-faceted endeavor whose integral nature is based upon a mix of social, economic, biological and conservation factors. Adequate monitoring of conservation tourism is necessary in assessing the relative success of socio-economic and conservation goals. Thus, the purpose of this research is to assess local perceptions and involvement in conservation tourism in Baja California Sur, to provide a baseline from which future success of the project can be gauged, and to incorporate local input into the development process of current and future projects. Face-to-face surveys and semi-structured interviews (n = 306) were administered in Loreto, San Ignacio and Todos Santos, BCS during the summer of 2008. Demographically representative surveys were conducted to retrieve information regarding local involvement, knowledge of conservation tourism, perceived benefits and negatives and desired outcomes. In-depth interviews with key informants were designed to provide detailed information about existing tourism and conservation projects, local infrastructure, resource use, and NGO and government involvement. Survey and in-depth interview results are reported from these three communities. Conservation tourism may be a viable option for many communities around the world facilitating a shift from consumptive patterns of resources to non-consumptive patterns, while simultaneously benefiting the local community. However, these projects should be implemented cautiously and monitored continually in order to avoid potential downfalls. This research will aid in this effort and provide a template for continued monitoring of the SEEturtles.org project and other conservation tourism projects.

## **SCHIZOPHRENIC MARINE TURTLES? ENDANGERED OR PLAGUE SPECIES?\***

**Jack Frazier**

Conservation & Research Center, Smithsonian Institution, Front Royal, Virginia, USA

Unending debates about what official category to attach to marine turtles – be it “critically endangered,” “endangered,” “threatened,” or “vulnerable” – are commonly based on dubious assumptions. One of these assumptions is typified by the usual banners of conservation programs: “So many eggs were saved this year” or “So many hatchlings were released this year.” Clearly, to be ecologically meaningful, figures must relate not to all turtles, or even to all turtles of just one species, but rather to a population or management unit. Moreover, conserving marine turtles may not be simply a matter of “managing” separate stocks: it is necessary to know how different stocks of the same species, as well as individuals of different species, interact with each other. Could it be that there is not only significant competition (e.g., for nesting sites, hatchling food, juvenile food, refuge sites, etc.) between individuals of the same management unit, but also significant competition between individuals of different species, or perhaps individuals of the same species but different management units? Might some marine turtle populations actually be functioning as plague species for other populations that actually are highly endangered? Studies of other taxa show that questions like these are essential for understanding ecological trends: the foundations of conservation objectives. If the best ecological information and theory is to inform and guide marine turtle conservation policies and activities, then these inconvenient questions must be addressed.

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## **EDUCATION, CONSERVATION AND RESEARCH ON SEA TURTLES IN FRENCH POLYNESIA: 3 MAIN GOALS DEVELOPED BY TE MANA O TE MOANA, A LOCAL NON-PROFIT FOUNDATION**

**Cécile Gaspar, Matthieu Petit, Nicolas Leclerc, and Vie Jourdan**

Te Mana o Te Moana, French Polynesia

Since 2004, biologists, researchers, engineers, educators and veterinarians have been joining efforts in French Polynesia on sea turtle projects managed by a newly founded non-profit foundation called “Te Mana o Te Moana” (“Spirit of the Ocean” in Tahitian language). Education, conservation and research are the main foci. Educationally, a new school program called “Honu Récré” has been developed. It has targeted lessons for each grade level and is taught either in the classroom or at the foundation, where turtles can be seen and treated. A new interactive DVD for teachers is currently being developed, which will be distributed widely in French overseas territories. An English version will also be available throughout the Pacific region. Our educators also developed seminars for teachers and high school levels. Our conservation objectives included setting up a sea turtle clinic with the help of the Polynesian Government to rescue sea turtles from any archipelagos in the Territory. To date, 130 turtles have been received and 45 have been successfully released after specific treatments. Our research team has been involved in sea turtle nesting programs and observations as well as in the creation of an observatory network. Key data are collected to better understand the nesting factors in French Polynesia to contribute to a better management plan by the local authorities.

## **ANATOMY OF A CONSERVATION SUCCESS STORY: LESSONS LEARNED FROM A HALF CENTURY OF COMMUNITY COLLABORATION, ECONOMIC INCENTIVE AND RESOURCE MANAGEMENT TACTICS AT TORTUGUERO, COSTA RICA\***

**David Godfrey<sup>1</sup> and Emma Harrison<sup>2</sup>**

<sup>1</sup> Caribbean Conservation Corporation, Gainesville , Florida, USA

<sup>2</sup> Caribbean Conservation Corporation, San Jose, Costa Rica

Founded in 1959 by the late Dr. Archie Carr and a group of his supporters, the Caribbean Conservation Corporation (CCC) is the world's oldest sea turtle research and protection organization. CCC is most renowned for its long-term conservation project at Tortuguero, Costa Rica, site of the longest continuous turtle monitoring and recovery effort. Over the last 50 years, CCC has developed, tested and refined numerous management and conservation strategies incorporating changing socio-economic, legal and cultural factors. Many of the lessons we have learned are relevant to sea turtle conservation around the world. In this paper, we will discuss the most effective management strategies used to help achieve a remarkable conservation success story at Tortuguero. In the 1950s, green turtles nesting at Tortuguero were heavily exploited and on a trajectory to extinction. Since 1970, however, green turtle nesting at Tortuguero has shown a documented increase of over 400%, making this colony the largest in the Western Hemisphere and the second largest globally. By building close relationships with the Government of Costa Rica and the community of Tortuguero, CCC has helped build a strong ethic of sea turtle conservation. With few exceptions, government and community leaders have embraced sea turtle conservation as an important component of the local culture and an equally important source of economic stability. We have helped develop complex economic mechanisms at Tortuguero to ensure local residents can participate in and benefit from turtle tourism. These mechanisms include a structured process overseen by local authorities to train, permit and regulate local guides who conduct organized turtle tours, as well as an associated tour system that helps minimize negative impacts from tourism on nesting turtles. Meanwhile, legal strategies have been employed to safeguard Tortuguero's nesting habitat and the turtles themselves from exploitation, including establishment of Tortuguero National Park to protect the nesting beach; a regional turtle conservation agreement among neighboring countries; a complete ban on turtle and egg harvesting at Tortuguero; and a development regulatory plan to control coastal construction and limit human encroachment along Tortuguero's coastal strand. CCC is an engaged member of the local community, as opposed to being an outside entity working in the area for a short period of time. Indeed, much of Tortuguero has grown up around CCC's presence and the turtle conservation program. As such, CCC is a vested stakeholder in helping to resolve social issues and preserve local culture. To build social connections, we involve local individuals, especially students, in the turtle monitoring and conservation program. CCC also is one of the most stable local employers in Tortuguero, thus providing an important direct source of income for many in the community. The lessons learned by CCC over the last half century at Tortuguero, including successes and ongoing challenges, offer insight for other groups conducting sea turtle research and conservation programs. While all situations include subtle differences, the legal, economic, social and cultural management strategies employed by CCC at Tortuguero offer important lessons for any long-term sea turtle project.

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## **THE INITIAL RESULTS FROM THE COMMUNITY BASED SEA TURTLES CONSERVATION PROGRAM AT BAI TU LONG AREA AND LESSONS FOR FUTURE ACTIVITIES**

**Tuan Hung Pham<sup>1</sup>, Thi Thu Hien Bui<sup>2</sup>, and Cuong The Chu<sup>3</sup>**

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Located at the north of Viet Nam and close to the world heritage Ha Long Bay, Bai Tu Long Bay is one of the greatest landscapes in Viet Nam with numerous wild islands with sandy beaches, and an abundance of terrestrial and marine

fauna and flora. In history, Van Don (a terrestrial part of Bai Tu Long) was a famous and important commercial sea port, as it connected Viet Nam to other countries in the Asian region and, as a result, the rest of the world. According to the report from Hong Kong custom office, in the beginning of 20 century, about a hundred tons of hawksbill shells have been imported from Van Don to Hong Kong every year before exporting to Japan. These shells and productions were mostly collected from Bai Tu Long area and surrounding. Moreover, according to previous studies, Bai Tu Long area was one of the few remaining nesting areas of two species of sea turtles (*Chelonia mydas* and *Eretmochelys imbricata*) in the North of Viet Nam. Acknowledging the important role of sea turtles and taking responsibility for the Vietnam Sea turtles Conservation Action Plan until 2010, Bai Tu Long National Park Management Board with technical and financial supporting from IUCN have been conducting a program to (1) Identify the important nesting beaches of sea turtles in Bai Tu Long area and surrounding; (2) Monitor sea turtles at offshore and inshore areas and (3) Raise awareness of local people and students at Quan Lan island for protecting sea turtles and habitats. This program has been conducted from 2006 to 2008 and achieved initial results. More than 1000 data sheets of offshore monitoring program have been collected; hundreds of students and teachers from Minh Chau high school at Quan Lan island, all staffs at Bai Tu Long National Park and hundreds of local people have been trained; 6 beaches at Bai Tu Long Bay and surrounding have been confirmed as remaining nesting beaches.

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## **THE IOSEA ONLINE REPORTING FACILITY: A CUTTING-EDGE TOOL FOR TURTLE PRACTITIONERS AND DECISION-MAKERS\***

**Douglas Hykle**

IOSEA Marine Turtle MoU Secretariat, Bangkok, Thailand

The IOSEA Marine Turtle Memorandum of Understanding now has 28 member States across the whole of the Indian Ocean/South-East Asian region. It is the world's largest intergovernmental agreement focusing on the conservation of marine turtles and their habitats. The agreement's state-of-the-art Online Reporting Facility has now been in operation for several years, offering unique insights into strengths and weaknesses in implementation. An overview of the key findings will be presented, based on a synthesis of comprehensive information submitted by the full IOSEA membership. A separate database containing site-based information on species, habitats, threats and mitigation measures provides a wealth of information needed for effective management – answering such important questions as: where precisely are turtles most at risk from serious threats, such as by-catch or unsustainable egg harvest?; where are the gaps in fundamental research?; where is there potential for exchanging information and lessons learned from common management practices (such as predator control, hatcheries, regulations on building location etc)? A brand new mapping interface using the latest advances in GoogleMaps and GoogleEarth projects the database contents in a highly versatile, visual format. Specific examples will be presented to illustrate the system's potential. Through the IOSEA Online Reporting Facility, marine turtle practitioners and decision-makers have unprecedented access to essential information needed for prioritizing management interventions in an environment of limited resources.

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## **COMPLIANCE AND ENFORCEMENT IN SEA TURTLE CONSERVATION IN FIJI\***

**Joytishna Jit**

University of Wollongong, Wollongong, Australia

Sea turtles will become extinct unless appropriate actions are taken to reverse the decline. This study assesses the existing framework and mechanisms for sea turtle conservation at the international, national and regional levels. The study is a combination of literature and legislative review, a case study of a traditional sea turtle fishing community, and interviews with key contacts. Local perspectives on sea turtle conservation in regards to culture, traditional knowledge, and socio-economic considerations are addressed to provide insight into the status of turtle conservation in the country. Sea turtles are a shared resource, therefore the international community is driving regions and nations to

take measures to minimise threats to sea turtles, especially bycatch. Fiji cannot afford to be left out of this action. The Western and Central Pacific Fisheries Commission (WCPFC) drafted a Resolution to mitigate the impact of fishing for highly migratory fish species on sea turtles. Existing sea turtle bycatch data and information in Fiji's tuna industry is limited, and measures to better monitor bycatch through greater observer coverage, improved fishing techniques and proper turtle handling onboard is needed. Although Fiji is not a party to the Convention on Migratory Species of Wild Animals (CMS), it is obliged under several other Conventions to conserve sea turtles domestically. The Secretariat of the Pacific Regional Environment Programme (SPREP) is leading the regional sea turtle conservation agenda. Worldwide Fund for Nature (WWF) has been working closely within the context of international environmental conventions to conserve sea turtles under its Asia-Pacific Programme. The regional initiative has been important in raising awareness and education among stakeholders and conducting research regionally. However, there are many gaps in scientific, ethnobiological and socio-economic research, legislation and policy, enforcement and compliance for sea turtle conservation in Fiji, limiting the effectiveness of sea turtle conservation initiatives. For example, the coastal community relied on sea turtles for their livelihood and the ban on domestic sea turtles was ineffective. The case study and other findings indicated that there were no mechanisms in place for the duration of the study to induce positive incentives for sea turtle conservation in Fiji's communities. It is recommended that inclusion of carefully planned sea turtle conservation strategies into the existing and otherwise highly successful, locally-managed marine areas network is necessary. All four species of turtles in the Fiji Islands are on the IUCN Red List. Green turtles and hawksbills are known to nest and forage in significant numbers in the country. There are gaps in the knowledge of local stock status, range and distribution. Local conservation of sea turtles is as old as its traditional exploitation, but changing circumstances over time have contributed to possible overexploitation of this valuable species, related to the increased importance of cash incomes and a greater demand for food. Sea turtle bycatch is probably also attributing to the decline.

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## **“SEA TURTLE 101”: EDUCATING AND ENGAGING A LOCAL COMMUNITY THROUGH AN IN-WATER SEA TURTLE RESEARCH PROJECT AT JOHN BREWER’S BAY, ST. THOMAS, U.S. VIRGIN ISLANDS**

**Kemit-Amon Lewis<sup>1</sup> and Paul Jobsis<sup>2</sup>**

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Sea turtles have been and are still hunted for a number of historically cultural and medicinal uses in many countries. Additionally, interactions with fishing gear and vessels, loss of nesting habitats, poaching, degradation of foraging habitats, pollution, and diseases have all contributed to global declines and are among the top local conservation issues in the US Virgin Islands. The three species (leatherback, green, and hawksbill sea turtles) commonly found in the United States Virgin Islands are all federally protected under the US Endangered Species Act of 1973 and locally protected under the Indigenous and Endangered Species Act of 1990. As keystone species in their individual habitats, most on or adjacent to coral reefs, their continued existence is important to the stability of those areas. These habitats, coral reefs and sea grass meadows, are important to both commercial and recreational activity throughout the USVI, in turn making them important to the economy. The local comprehensive, long-term sea turtle studies have all been focused on nesting beaches. The most recent in-water study by Lewis and others, conducted in 2005, identified John Brewer's Bay as a key recruitment and foraging site for green sea turtles. Brewer's Bay, on southwest St. Thomas, is also the location of the island's campus of the University of the Virgin Islands (UVI). The current in-water research project was designed to study the foraging population of green and hawksbill sea turtles at John Brewer's Bay while engaging the local community through education and participation. On four separate occasions volunteers gathered at the UVI Center for Marine and Environmental Studies. A brief lesson was prepared that gave an overview of the biology of the locally found species, historical uses, and conservation issues. Video of a previous in-water capture was used to demonstrate how to safely catch a sea turtle. To date, more than 86 volunteers (ranging in ages from 10 to over 70) have assisted in or observed the successful free-dive capture, processing, and release of 37 sea turtles (25 greens and 12 hawksbills). As a result of the project the “UVI Turtle Squad” was also formed, which has conducted thirteen swim surveys. The swimmers observed an average of 6.5 green and 1.7 hawksbill sea turtles per hour swim. Additionally, Dr. Doug Innucci, a professor at the University, has kept a log of sea turtle sightings on each of his swims, averaging 21 swims per month. To date he has observed an average of 2.3 sea turtles per swim. We plan on expanding this project to other local sites to better understand the foraging populations and migratory behaviors of sea turtles throughout the U.S. Virgin Islands. It is our effort to foster a better appreciation for sea turtles and their local,

regional, and global importance by keeping local community involvement a strong component of this in-water sea turtle research project.

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## **EFFECTIVENESS OF CONSERVATION MEASURES FOR SEA TURTLE MANAGEMENT: THE EXAMPLE OF ITSAMIA, MOHELI - COMOROS UNION**

**Anfan M'soili<sup>1</sup>, Cyril Marmoex<sup>2</sup>, Marie Lauret-Stepler<sup>2</sup>, Francois Beudard<sup>2</sup>, Stéphane Ciccione<sup>2</sup>, and Jérôme Bourjea<sup>3</sup>**

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<sup>3</sup> IFREMER La Réunion, France

Following the examples of international conventions (Nairobi convention, Biological Diversity convention, Stockholm convention, CITES convention...) that encourage local communities to manage their natural environment, Comoros Union decided to promote the integrated management of coastal resources. On Mohéli Island, the Association for the Socio-Economic Development of Itsamia ("ADSEI") chose the marine turtle as a flagship species. The main objectives of ADSEI are to: develop the economy of Itsamia; reinforce and maintain the solidarity within the village; increase awareness of the Comoros people of the scientific and economic importance of endemic and endangered species through tourism; and preserve the environment with a focus on birds of MChako Rock, the ducks and dry forest of Boudouni lake, and the marine turtles of Itsamia beaches. The global objective is the conservation of terrestrial and marine natural resources for sustainable development and local community wellbeing. Since a training period funded by PRE-COI (Regional Program for Environment of Indian Ocean Commission) and performed by CEDTM (Marine Turtle Survey and Discovery Centre of La Reunion) and Ifremer (French Institute for Marine Researches) in 1998, a monitoring program was implemented on 5 beaches of Itsamia. Since that date, turtle tracks are counted daily and more than 5,000 turtles were tagged by ADSEI members in collaboration with CEDTM. Data were recorded in a database managed by ADSEI. The initial analysis of these data shows that Itsamia remains one of the major nesting sites for green turtles in the southwest Indian Ocean. Due to the abundance of marine turtles and the gained field experience, Itsamia remains a pilot site for protection against poaching, marine turtle monitoring and natural resources valorisation.

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## **IMPLEMENTING INTERNATIONAL INSTRUMENTS IN MANAGEMENT OF SEA TURTLES OF THE WESTERN INDIAN OCEAN REGION\***

**Jane R. Mbendo**

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Efforts to conserve sea turtles globally can be more effective if coastal States take into account the principles and provisions in existing international instruments and legal framework. Sea turtle populations are continually impacted globally by human activities such as illegal harvesting of turtle eggs, habitat alteration and incidental capture in fisheries, with fisheries interactions contributing significantly as a threat to sea turtle mortality. These threats impact sea turtles as they migrate long distances across borders to forage and nest. Their migratory nature presents management challenges that require both national management and an international cooperative management regime between neighbouring coastal States and foreign fishing nations alike, to ensure sustainability of the species. The five endangered species of sea turtles occurring in the WIO are: green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), and loggerhead (*Caretta caretta*) turtles. Efforts to address management and conservation of sea turtles in the Western Indian Ocean (WIO) were initiated at the 1995 regional meeting at Sodwana Bay, South Africa, where the Sodwana Declaration was endorsed in support of the 'WIO Strategy for the Conservation of Marine Turtles'. The IUCN Marine Conservation Strategy and Action Plan for the WIO was then formulated to prioritise the areas for regional action regarding sea turtles. Individual coastal States followed this with their national action plans, in which most have maintained the involvement of all

interested parties in civil society and government alike. Kenya, for example, developed its sea turtle recovery action plan soon after this. Even after the endorsement of the Declaration, the WIO States have acted in isolation regarding the conservation of sea turtles despite calls for regional cooperation and the existence of suitable organisations and the commitment of these States to international instruments. In response to threats resulting from fisheries interactions, the Law of the Sea Convention imposes obligations on coastal States and other States whose nationals fish in the region to cooperate to ensure the effective conservation and sustainability of migratory species. The principle underpinning international instruments governing the conservation of sea turtles are the obligations to conserve and a duty to cooperate. Regional cooperation in regards to tuna fisheries is achieved through the Indian Ocean Tuna Commission. In addition, most of the WIO coastal States have signed the Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA), which was adopted in 2001 under the auspices of the Convention on Migratory Species. The coordination efforts of IOSEA have been instrumental in the formation of the WIO Marine Turtle Task Force whose mandate is of an advisory in nature. This paper suggests that WIO coastal States can co-operate more fully in the sustainable management of sea turtles if the priority actions set out in the WIO strategy are fully implemented and their international obligations met, especially since the regional framework does exist.

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## **RE-ESTABLISHING SEA TURTLE CONSERVATION EFFORTS IN PULAU BANYAK, ACEH, SUMATRA, INDONESIA**

**Maggie Muurmans and Mahmud Bangkaru**

Yayasan Pulau Banyak, Aceh, Indonesia

Yayasan Pulau Banyak (The Banyak Foundation), a local Indonesian NGO, has only recently set up a beach monitoring and tagging programme for Pulau Banyak, an archipelago off the southern coast of Aceh (Sumatra). The beach provides a nesting area for green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys coriacea*) turtles and is protected through the beach patrol team of the foundation, who work in conjunction with the forestry department and ministry of fisheries. The first information on the rookery of Pulau Banyak was collected in 1997, and recent information is more complete due to the tagging programme and nightly beach patrols. Information on the nesting population has been collected since December 2007, including nest counts. The tagging programme started in February 2008 and continues today. The beach patrol team consists merely of Indonesians and occasionally international volunteers who assist in the data collection. An eco-tourism programme has been developed around the sea turtle conservation programme, providing an alternative income to the community. Other social programmes have also been involved such as an environmental education programme and cultural and sports activities. This resulted in a full support of the local community towards all conservation initiatives of the foundation such as sea turtles, dugong, coral reefs and forests. First data indicates that Pulau Banyak, Pulau Banyak's main nesting site, represents a significant nesting rookery for the green turtle. From December 2007 until August 2008, 1171 nests have been counted. Peak season (May to July) is similar to Eastern Indonesian green turtle rookeries.

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## **THE GEORGIA SEA TURTLE CENTER, 1 YEAR LATER**

**Stefanie A. Ouellette<sup>1</sup>, Terry M. Norton<sup>1</sup>, William P. Irwin<sup>2</sup>, Michelle Kaylor<sup>1</sup>, Erika Kemler<sup>1</sup>, Alicia Marin<sup>1</sup>, Sarah Mathias<sup>1</sup>, Jeannie Miller<sup>1</sup>, and Kelly O'Keefe<sup>1</sup>**

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The Georgia Sea Turtle Center (GSTC), the first of its kind in Georgia and possibly in the world, has a mission statement that says it all: "Through sea turtle rehabilitation, research and education programs, the Georgia Sea Turtle Center will increase awareness of habitat and wildlife conservation challenges, promote responsibility for ecosystem health and empower individuals to act locally, regionally, and globally to protect the environment." The facility officially opened to the public on June 16, 2007 and has experienced noteworthy accomplishments and amazing success in just the first year alone. While the facility itself is housed within a rehabilitated historic building in the

Historic District of Jekyll Island, Georgia, there is nothing historic about the equipment inside. A state-of-the-art facility, our hospital contains high-tech life support systems, digital x-ray capabilities, flexible and rigid endoscopy, ultrasound, a surgical suite, a treatment room and equipment to conduct numerous diagnostic tests on site. Collaborations with a local dentist, orthopedic surgeon, CT and MRI facilities, who donated their time and equipment, have led to new techniques and procedures. Relationships with several veterinary schools allow us to utilize the expertise of various specialists and train veterinary students in wildlife medicine and conservation. These affiliations have enabled us to forge the cutting edge of innovation and invention in new rehabilitation techniques on age-old patients. Our Research Department is working to assess the nesting population on Jekyll Island with a nest monitoring and saturation tagging program, human impact study, and a loggerhead nutrition study. In addition, we partner with outside researchers on projects including DNA studies and hatchling locomotion. We are leading a cooperative effort to standardizing the approach to handling sea turtle mortality events. We are also working to establish a comprehensive program for marine bird health and disease surveillance in Georgia. The Exhibit Gallery houses custom-made, interactive exhibits featuring the life history of sea turtles, life-sized reproductions of sea turtles species found in Georgia, and a full-sized replica of *Archelon* suspended above our Gift Shop. Unique features of the GSTC include a Treatment Room window and an elevated walkway in the center of our Rehabilitation Pavilion, allowing us to engage the general public by giving them a close up, personal view of the rehabilitation process, enhanced by education programs. The Education Department also coordinates school and tour groups, outreach programs, teacher workshops, family programs, summer camp and special events. The GSTC has been involved in several international training workshops in the Caribbean and Panama. We have partnered with Ross University, WIDECAS, and others in the development and ongoing efforts of the St. Kitts Sea Turtle Monitoring Network by providing expertise and staff in leatherback and hawksbill tagging and health assessment projects. The GSTC has also evolved to include freshwater turtles, diamondback terrapins and tortoises in its rehabilitation, education, and research programs. Most notably is the development of a comprehensive conservation program for the diamondback terrapin. The GSTC also hosted a Diamondback Terrapin Road Mortality Workshop and a Gopher Tortoise Council Annual Meeting in 2008.

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## **A NATIONAL COMMUNITY-BASED SEA TURTLE CONSERVATION PROGRAMME IN VANUATU**

**George Petro**

Wan Smolbag, Port Vila, Republic of Vanuatu

Wan Smolbag Theatre (WSB) is a community based educational drama group which has been working in Vanuatu since 1989 bringing plays on governance, health and environment issues to the people in order to promote community discussion and action. Based in Port Vila on the Island of Efate, WSB operates in the media of theatre, video and radio. WSB's turtle monitoring program started in 1995 following SPREP's declaration of the first Pacific 'Year of the Sea Turtle.' At this time, a sea turtle drama was produced to raise awareness of conserving turtles at the community level. To develop the 'Turtle Play', the WSB actors first went to villages around North Efate researching information and stories about turtles. The actors spent a number of days engaging communities in informal discussions on turtles. These initial visits centred on gathering information: how much did people know about turtles? Were there customary stories and cultural practices about turtles? How many turtles were people seeing? This was an important step in the process of producing the play, as it ensured community involvement and a feeling of ownership for this new initiative. The actors were also able to identify what information needed to be addressed in the play. The actors then took the play out to the communities of North Efate. After each performance, the WSB actors helped each community choose one or two residents to act as 'Turtle Monitors'. The monitor's role is to encourage turtle conservation and to monitor turtle activities in their communities. This was how the Vanuatu turtle monitoring network program began. Since the late 1990s the programme has expanded from the Island of Efate to the other outer-islands in Vanuatu. This stemmed from the knowledge that turtles are migratory species and their conservation and management would require the collaboration of communities on the other islands. Currently there are over 200 community-based turtle monitors in Vanuatu, and the network is still expanding into new areas each year. In the year 2000, the turtle monitors adopted the name Vanua-Tai Resource Monitors (VTRM), "Vanua" meaning land and "Tai" referring to the sea. The name change reflects the monitors' increasing roles in their communities in monitoring and conserving sea turtles along with other marine and terrestrial species. Activities under the VTRM turtle conservation work include: a national turtle tagging program, annual nesting beach surveys, annual turtle monitoring workshops, turtle awareness and education in communities and schools, a community based international eco-tourism nesting beach survey project, etc. Recently the Fisheries department has updated its turtle regulations to include a total ban on the killing of leatherback turtles, and the

requirement for any turtle harvesting associated with cultural activities to be approved by the Director on a case by case basis. This has been a boost to the ongoing turtle conservation work in their respective communities and has created a collaborative effort between WSB, the Fisheries department and the local communities in monitoring and conserving sea turtles in Vanuatu and the Pacific as a whole.

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## **RECOVERY, DE-LISTING, AND THE BEST AVAILABLE SCIENCE DEBATE IN SEA TURTLE CONSERVATION\***

**Alison Rieser**

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Among the many policy questions left unresolved when sea turtles were listed on the U.S. endangered species list was whether an exception should be made for subsistence or traditional cultural uses of sea turtles by people who live near turtle nesting beaches and foraging grounds. Because local harvesting of sea turtles and their eggs is not international trade, it is not governed by the CITES Appendix status of a given species. Each nation with nesting or foraging populations under its jurisdiction must therefore decide whether to curtail subsistence or traditional uses of sea turtles by local people in order to promote the global conservation goal of recovering endangered species. Although not a biological or ecological question per se, sea turtle biologists have contributed to this debate when it has arisen in communities near their field sites. In the U.S., managers have not had to address this question in several years, but there are signs that it may soon become an issue for at least one recovering population. In the 1990s, the U.S. successfully prosecuted a Native Hawaiian for killing a green sea turtle (*Chelonia mydas*) for personal consumption. This case occurred shortly after the U.S. government decided not to extend to Hawaii and Guam the exemption that Pacific island turtle fishers had been given in the U.S. trust territories on grounds that turtles were not a necessary food source. This U.S. policy is in contrast with the Australian government's cooperative sea turtle management in Aboriginal communities in northern Australia whose customary marine tenure has been legally recognized by the Australian courts. Recent studies have shown that the Hawaiian green turtle population has begun to recover from decades of overexploitation and that for management purposes it is likely to be a discrete and significant unit. But in at least one paper, scientists have taken a step beyond data analysis by suggesting that a sustainable harvest may be possible in the near future. Other researchers present these trends as "good news for sea turtles" although a series of challenges, such as disease, marine debris and sea level rise, remain for this and other recovering populations. These conditions suggest that any proposal to de-list the Hawaiian green turtle is likely to be very controversial, clouding the policy debate on the role of local subsistence use and management in the global conservation effort.

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## **PROTECTING NESTING LOGGERHEADS ON BOA VISTA, CAPE VERDE USING MILITARY PRESENCE**

**Christian Roder**

Turtle Foundation (Ammerlander Hauptstrasse 1, D-82541 Münsing, Germany)

The Cape Verde Islands are considered to support the third largest nesting population of loggerheads (*Caretta caretta*) in the world. The most serious threat facing nesting turtles on Boavista Island is exploitation for meat and eggs by the island community even though their survival does not depend on it. In 2007, over 1,100 females were estimated to have been slaughtered on the beaches of Boavista Island, representing approximately 36% of the nesting turtles on the island. To address this urgent issue, the Turtle Foundation established a beach protection program in 2008 on Boavista to protect 10 km of the eastern coast where an estimated 600 females were slaughtered in 2007. The primary objective for the 2008 nesting season (July-October) was to prevent the killing of nesting turtles with help from the Cape Verdean military. Additionally, the Turtle Foundation conducted random checks of vehicles coming from the beaches at night in collaboration with the local police. Beach patrols by the military and vehicle checks appeared to decrease turtle take significantly during the 2008 nesting season. At the end of the nesting season, the perceptions of the local community towards military presence on their beaches and their attitude towards the Turtle Foundation project were evaluated. This information will be used to modify conservation activities, to implement approaches that will

effectively reduce the exploitation of turtles, and to develop a long-term, sustainable sea turtle program that has the support of the local residents of Boavista.

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## **DHAMRA PORT: HOW ENVIRONMENTAL REGULATORY FAILURE FUELS CORPORATE IRREVERENCE\***

**Sudarshan Rodriguez and Aarthi Sridhar**

Ashoka Trust for Research in Ecology and the Environment, Bangalore, India

India's environmental regulatory framework defines the country's priorities towards the environment and only provides a signal for companies to follow. How diligent are the 'due diligence' practices outlined for port developers? The site of the proposed Dhamra Port project is located on the eastern Indian coast of Orissa, north of the River Dhamra and is about 13 kilometers away from the Nasi group of islands, the Gahirmatha Marine Sanctuary (one of the world's largest mass nesting sites for olive ridleys) and just 4 kilometers from the Bhitarkanika National Park, one of the two significant mangrove ecosystems in India. The controversies over the Dhamra port are a result of lacunae in the environmental laws, litigation processes and in the nature of engagement over environmental decision-making in the country. It is closely intertwined with the regulatory environment which at present is designed to fail, with gaps in its legal text, poor implementation and monitoring framework besides other systemic issues such as corruption. The Dhamra case poses many fundamental challenges. Is it possible to expect an integrated and meaningful operation of conservation and environment protection in a regulatory framework? What is required to integrate legislation, clearance procedures, implementation and compliance mechanisms and development planning? The regulatory frameworks and regulatory bodies need to demonstrate that environmental protection is the social norm. Only then will corporations respect and follow environmental protection policies. The Dhamra Port case is an isolated event of mere corporate irreverence towards the environment. The project is only an illustration of a larger trend and should be juxtaposed with the overall scenario of coastal development with specific reference to ports in the State of Orissa as well as rest of the Indian coast. It should also be seen as part of a trend of undermining conservation and environmental protection measures in the coastal management legislation which has serious implications for sea turtle conservation. The work involves a thorough analysis and review of the current processes, reports and documents relating to the project. An overview with statistics on port development in India and historic trends in the coastal regulatory framework and the current "reform" process (with specific references to sea turtles) are presented which will emphasize the need to move the current focus on conventional site-specific threats to sea turtle conservation to larger, intense and perhaps irreversible ones that result from inappropriate coastal development planning and inadequate environmental regulation (by design and implementation).

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## **CHILDREN, MARINE TURTLES AND MAIL FOR A COMMON OBJECTIVE: RESCUING THE HAND WRITTEN LETTER AND NATURAL RESOURCES**

**G. Tiburcio Pintos<sup>1</sup>, J. Alcantar-Armenta<sup>2</sup>, S. Carter<sup>3</sup>, A. Barrios<sup>4</sup>, M. Arrecis<sup>5</sup>, and S. Sankaran<sup>6</sup>**

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The Marine Turtle Protection Program of H. X Ayuntamiento de Los Cabos, Baja California Sur-Mexico, is beginning a new project through which children of different countries are united by way of exchanging hand-written letters. Through this program, sixth grade students of a primary school in Los Cabos, Mexico send letters by mail to students in the United States, Costa Rica and Guatemala, and receive letters in return. In their letters, they describe the area where

they live and share with each other stories about their experiences with sea turtles. The first exchange was carried out between the Colegio Mission of Los Cabos, Mexico and the Point Dume Marine Science School in Malibu, California, U.S.A. Forty-six children participated from each school making a total of 92 children in the program. Six mailings were accomplished (3 to the U.S.A. and 3 to Mexico) by which 414 letters total were exchanged. The second correspondence was carried out between 35 students of the Fernando Burgoin Montaña School of Los Cabos, Mexico who wrote to 35 children from the Tortuguero School in Tortuguero, Costa Rica. They participated in 4 mailings (2 to Costa Rica and 2 to Mexico) which included 280 letters total. The public's interest in this project has been generated through the media, and is so great that currently we are initiating a program with classes from Guatemala in the areas of Aldea el Conacaste, Punto Iztapa, Puerto Barrios, Izabal and Muyuta-Jutiapa with a total of 100 letters which will be received by Mexican children soon. The children's capacity for creativity has no limits – the letters are full of color and detail and include everything from perfumes to information from school, photographs, drawings, and even little souvenirs. They share ideas and ask each other questions. There are no words to describe the students' excitement upon receiving the letters. Apart from getting to know other people from different places and cultures, as well as more about sea turtles, this program inspires the children's imagination and stimulates them to write letters by hand, a skill which has become somewhat neglected due to the internet. Our initial objective was to motivate hand-written correspondence and that participants share information about different species and forms of protection of sea turtles in their countries. However, this program has additionally served as a unique educational tool with diverse benefits for the children that have been truly surprising and inspiring. The Sea Turtle Protection Program has given children from these countries a way to share new words and concepts, practice another language (English and Spanish), gain knowledge of another currency and its value, develop an understanding of other ecosystems and their diversity, learn geography, make new friends, and has served as an overall invaluable cultural exchange.

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## **MARINE CHELONIAN ILLUSTRATION-PART SEVEN: SEA TURTLES – IN A LINNEAN STATE OF MIND**

**Chuck Schaffer<sup>1</sup> and Rick Schaffer<sup>2</sup>**

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Known written accounts predate the classical Greek period, although accompanying images are not extant. As early as the time of Aristotle and Pliny, humans sought to understand the workings of nature, and by extension, chelonians. We have their words, but any images have been lost. Then the Dark Ages set mankind several steps back. After this, a mythological approach appeared in medieval bestiaries such as those of de Cantimpré (1240), van Maerlant (1350), and Candadus (1460), this time in religious morality lessons. But eventually the path to science began again, appearing in the fifteenth century natural histories and encyclopedias of Gessner, the father of Modern Zoology. His work, *Historiæ Animalium* (1555), laid the foundation for standardization of scientific terminology. He combined classical and medieval literature to his own observations and those of correspondents. This wealth of knowledge was then organized in a precise manner: synonymy, distribution, physical characteristics, habits, use as food, medicine, etc. His effort was the first illustrated work of its kind covering the whole animal kingdom. Its influence continued for centuries providing text and models of animals copied by many of those whom he preceded, as he did of his predecessors. This was followed by the great Cabinets of Curiosities and Encyclopedias of Collaert (1610), Aldrovandi (1639), Jonston (1660), Flamen (1664), Gottwaldt (1714), Seba (1735), Diderot & Alembert (1751-1772), Edwards (1751), Knorr (1754). All of these included turtles in a general zoological overview approach. Exploration of the new world spawned the travelogues and regional works of deBry (1595; 1601), Commelin (1645), Dapper (1673), Catesby (1743), some including excellent natural histories. The three earliest chelonian anatomical works were completed by the late seventeenth century, (Caldesi, 1687; Perrault, 1688; Gottwaldt, 1781). Several of them (such as Gesner) were taxonomists, predating Linnaeus by two centuries. Some early methods utilized Latin words to describe organisms, but all were cumbersome and inconsistent. The first widely published binomial nomenclature, attributed to Bauhin, emerged early 17th century. This system was later adapted by Ray, who utilized a morphological approach. Linnaeus built upon these previous efforts refining them multiple times to arrive upon a system of standardized "generic" and "trivial names" and establishing the modern system of binomial nomenclature. The four testudinid names in the first edition of *Systema Naturae* (1735), progressed to eleven in the tenth (1758), and fifteen in the twelfth (1766) editions. Of these, eleven are currently considered valid with one genus (generic) and ten species (trivial names) being credited to Linnaeus. From these humble beginnings, the number of genera and species has grown to over 100 and 300 (depending upon whom one counts as the authority). Although he built upon the work of his predecessors, Linnaeus is

considered the father of modern systematics and thus that of testudine taxonomy. This presentation explores the evolution of his work with a survey of sources utilized by Linnaeus and those not included.

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## **A FLAGSHIP, A PORT AND A UNION - CONSERVATIONS AND CORPORATIONS: COLD WAR OR COMMON CAUSE?\***

**Kartik Shanker**

Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India

Olive ridley turtles nest en masse at several beaches in Orissa, mainly Gahirmatha, Rushikulya and Devi River Mouth. During the last three decades, the nesting population at Gahirmatha has been alternately and sometimes simultaneously referred to as the 'world's largest' and as 'highly endangered'. Other commentators have warned of the danger of creating hype and the negative impacts of conservation rhetoric in Orissa. In the last decade, the development of a port at Dhamra, close to Gahirmatha has been a cause for concern amongst sea turtle conservationists. The company leading the port project, the Tata Group, attempted to engage with conservation groups. NGOs however demanded that Tata/Dhamra Port Company Limited (DPCL) stop construction until studies were completed, pointing out that if construction were to continue, the company would eventually claim that there had been too much investment to stop even if studies were to show negative impacts on turtles. Over a 2 year period, neither side was willing to alter their position. Eventually, the Tata/DPCL contracted IUCN to advise them on mitigatory measures towards turtle conservation. IUCN's involvement led to considerable protest from local conservationists and experts as their objections were ignored. The IUCN team included international experts from the Marine Turtle Specialist Group; this was also controversial as local MTSG members were not consulted during this process. It is interesting that conservationists and corporations both place science on such a high pedestal, when it is unlikely that any results will be completely unequivocal about the impact of the port on sea turtle conservation. It is alarming that all these agencies, but particularly conservationists, would ignore all other potential impacts on other coastal and marine biodiversity. It is equally alarming that all other coastal development, including several ports, would be given such scant attention. This case demonstrates that conservation organisations have a lot more in common with corporations than they would like to believe, particularly in the way that they like to use information selectively. Sea turtle conservation in Orissa certainly seems driven by rhetoric rather than rationale. Large international conservation organisations also have much in common with corporations, especially in the way they function and make decisions. Do all the players (the state, conservationists, corporations, academics, fishers) intentionally or institutionally continue to pursue agendas and strategies that are geared to helping them regardless of whether it helps sea turtles in the long run or not?

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## **COASTAL REGULATIONS AND TURTLE CONSERVATION IN INDIA – IMPLICATIONS OF ONGOING REFORMS**

**Aarathi Sridhar<sup>1</sup>, Manju Menon<sup>2</sup>, Sudarshan Rodriguez<sup>1</sup>, and Seema Shenoy<sup>1</sup>**

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India's coast is governed by several official legislations that regulate 'development' activities including construction, industrial activity and coastal infrastructure. Some of these legislations have an explicit mandate to protect the coastal ecology and available natural resources of the region. Other laws govern the establishment of projects and schemes to use these resources for the growth of the local and national economy. One such protective legislation is the CRZ Notification that was promulgated in 1991 using the provisions of the central Environment (Protection) Act (EPA), 1986 and the Environment (Protection) Rules, 1986. Through such a notification, the coastline of the country was identified as an ecologically sensitive area, where development activities were regulated. The CRZ Notification is more than two decades old but has been one of the most significant and well-known notifications among several others enacted under the EPA, 1986. In the densely populated coastal belt, the regulation of developmental and industrial

activities through the CRZ Notification has provided critical protection for several coastal areas and consequently coastal ecosystems and species. The CRZ Notification especially recognised the need to protect sea turtle nesting beaches, providing much needed protection to beach areas not covered under any Protected Area category. However, recent studies that we conducted along with declarations issued by fisher and coastal communities and even judicial pronouncements have established that the original CRZ Notification, 1991 was abysmally implemented by the Indian Ministry of Environment and Forests (MoEF) and state governments despite Supreme Court directions and numerous High Court orders. The MoEF proposes to introduce a new law that seeks to replace the CRZ Notification and revise the structure, provisions, approach and perspective of the CRZ Notification, 1991. Environmentalists and legal experts have cautioned against the new notification. The proposed new Coastal Management Zone, 2008 Notification, has a long and unsavoury history. In the wake of its controversial environmental “reforms” initiative, the MoEF, which has faced great pressure to rescind the CRZ Notification, 1991, constituted the Swaminathan Committee to review the CRZ Notification and suggest changes to strengthen it. We examined the process followed in the promulgation of the CMZ Notification, 2008 and the departure from the original notification of 1991, sparked by the review process undertaken by the MoEF. We examine whether the clauses of this notification are adequate to protect coastal habitats and species such as sea turtles and their nesting grounds. The notification is controversial and proposes to undo the existing Coastal Regulation Zone Notification, 1991 which citizen groups have fought hard to implement. Is the proposed CMZ Notification designed for better coastal management? What evidence exists to show that conservation and sustainable livelihoods are the objectives of this law? This paper examines the content and process behind this new law to reveal concerns with the intent of this law. We provide the implications of the present draft notification’s provisions for coastal communities and ecosystems using our critiques of the various drafts of this notification.

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## **STATE OF *CHELONIA MYDAS* (GREEN TURTLE) IN FRENCH POLYNESIA CONTRIBUTION OF NGO TE HONU TEA TO ITS STUDY AND PROTECTION**

**Alexandre Tayalé and Sophie Gagne**

<sup>1</sup> NGO Te Honu Tea, Taravao, French Polynesia, France

In 2001, the creation of NGO Te Honu Tea was based on following reports: a dramatic decrease of the stock and an increase of the human pressure on the green turtle stock of French Polynesia. In the early 90’s, several authors estimated that the stock had decreased by 94% in 25 years (Balazs, EVAAM). However, the available data remain very insufficient to estimate the actual stock level and its geographical distribution in order to elaborate an efficient conservation strategy. The main threats are the capture of adult turtles and eggs harvesting (consumption and black market sales on local level). The increase of fishing activity is due to technological progress, imperfect knowledge of the species’ biology and neglect of traditional methods of environmental control. Since 2006, NGO Te Honu Tea developed actions for in-situ studies and protection: on Tikehau atoll, the study undertaken by Te Honu Tea since 2006 was the first monitoring covering a complete nesting period. It revealed a very low stock level and a high capture rate. On Vahanga and Mataiva atolls, prospection at the end of the nesting period brought a first estimation of nesting activities in the area. Te Honu Tea also realized a feasibility study of Green turtle breeding projects in French Polynesia (2008), which showed that the breeding of Green turtles in French Polynesia would imply high costs for uncertain ecological benefits. Last but not least, Te Honu Tea makes efforts to improve public awareness on a local level through the employment of local agents and partnership with local organizations, educational actions in school and development of teaching material and participation in public events (World Environment Day).

## **DEVELOPING A SEA TURTLE RESEARCH NETWORK IN THE SOUTH ATLANTIC**

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Our knowledge of sea turtles in the southern Atlantic is relatively poor compared to the northern Atlantic. To address this deficiency and establish transatlantic research collaborations, the South Atlantic Sea Turtle Network was created, and its first Workshop was held in Praia do Forte, Brazil, in May 2008, in collaboration with Projeto TAMAR. This first workshop focused only on loggerheads and leatherbacks and brought together 27 researchers working or collaborating on projects in South America and Atlantic Africa. The objectives of this first workshop were to map the knowledge of sea turtle distributions and threats, to develop research priorities so that individual projects become part of a larger regional initiative, and to assist African researchers. This workshop was the first in a series of workshops to catalyze transatlantic partnerships that will allow us to better understand and manage sea turtle populations in the southern Atlantic.

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## **PROTUMAR: 6 YEARS OF COMMUNITY PARTICIPATION ON SEA TURTLE CONSERVATION IN THE COAST OF OAXACA, MEXICO**

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The Sea Turtle Protection and Conservation Program (PROTUMAR) from the Network of Oaxacan Wetlands operates through community groups for the rescue of endangered clutches of different species of sea turtle that nest on the beaches of Oaxaca, Mexico. The Network emerged in 2002 as an initiative from several coastal communities concerned for the environmental deterioration of the wetlands and associated natural resources. With the support of government institutions and NGOs they started activities such as mangrove reforestation, recollection of solid debris and protection of sea turtle nests. The first sea turtle protection season in 2003-2004 involved three communities, and by 2006-2007 five community turtle camps obtained government permits to legally operate. With the current nesting season, 2008-2009, we celebrate 6 years of community work regarding the protection and conservation of sea turtles in Oaxaca, with plentiful results as a grassroots effort to avoid the extinction of these species in our region as well as to lead the path in contributing the development of communities and sustainable use of resources. The work of the Network has received recognition from the Federal and State governments, academic institutions, and has allowed the community members to have voice in different forums for decision-making.

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## **BUILDING BRIDGES: SEA TURTLE CAPACITY BUILDING AND ENVIRONMENTAL EDUCATION OUTREACH, PATOK ALBANIA**

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Regional cooperation in addressing threats facing the marine environment and endangered sea turtle species is paramount. Few project objectives involving local communities and international researchers could be effective, long-term, without an educational, capacity-building component. Under the Monitoring and Conservation of Important Sea Turtle Feeding Grounds project in the Patok Area of Albania, May to October 2008, capacity building and environmental education outreach played a key role in building bridges between local fisherman and the principle researcher and field-team. A full time Albanian researcher was employed for developing project management skills. Despite its richness in biological and landscape diversity, Albania is considered to have the highest rate of biodiversity loss in Europe. Educational programmes are needed to provide the population with some kind of incentive to preserve its rich biodiversity; this should include the conservation of sea turtles and their habitats in Albania. Collaboration with the University of Tirana enabled undergraduate biology students to visit the site, despite difficult road conditions, drawing local media crews to conduct documentaries and news spots. This project drew on the knowledge of a sea turtle specialist to demonstrate sea turtle handling, measuring, and photo-recognition techniques, as well as lectures on biology, ecology and the presence of *Caretta caretta* at Gjiri i Drinit. Three groups of students were present (50 on the 3rd of June, 50 on the 4th June, and another 50 on the 21st of June, 2008). There was a useful teaching opportunity on the second day, when a juvenile green turtle *Chelonia mydas* was released and aspects of its morphology and behaviour could be compared with those of loggerhead turtles. The university visits were televised on all three days. Releasing sea turtles after learning their biology is an effective experiential way of building understanding and affinity for this flagship species. The principle researcher established trust by accompanying local fishermen daily to check the traditional stavnik fish traps. Fishermen from other regions were drawn in to the project through local fishing associations and word of mouth. Collaboration on a local level with fishermen was essential as 99% of sea turtle captured were caught incidentally in the stavnik fish traps. Working on a local level in environmental education and outreach has the benefit of working on the grassroots level, effectively bypassing any difficulties faced in environmental education on a nationwide scale.

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## **A FIRST EVALUATION OF THE KNOWLEDGE AND USES OF SEA TURTLES IN COASTAL COMMUNITIES OF SINALOA'S NORTH, GULF OF CALIFORNIA, MEXICO**

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The Gulf of California is an important area for foraging and development of sea turtles. Since 2005 we initiated an integral project to evaluate a zone of Sinaloa's North without previous studies, with the intention of identifying and ranking the threats to sea turtles, as well as to design and put in practical plans of managing on the base of the problems and the priorities of attention determined by this first contact. We present the results of a random and structured survey applied to fishermen of five coastal communities of Guasave's municipality. The local knowledge related with: a) diversity and abundance of sea turtles, b) the direct and incidental extraction of sea turtles c) historical and recent habits

of consumption, d) knowledge of the legal frame and f) evolution of the role of the sea turtles in the processes of the local socialization, they constitute the informative nucleus of our survey. We got responses from 51 fishermen with an interval of predominant age from 41-50 years. Exists a local knowledge of the diversity of species (5) reported for the Gulf of California. They recognize that the abundance of olive ridley and black turtle is higher than hawksbill, leatherback and loggerhead. They know that the height of the black turtle, olive ridley and hawksbill varies from small juveniles to adults. 92% agree with the actual populations and are significantly less than in the 80's. 82% admits that they fish sea turtle as target activity. 78% fish all the year long with illegal fishing nets for fish. 11% use special nets for sea turtles. 41% capture 1 or 2 sea turtles per week during fishing seasons. They mention that the bycatch increases from September, with the shrimp fishery, in open sea for ships and the use of trawling nets and in coastal waters with boats and a great variety of fishing methods. 54% of them coincide with the low abundance of sea turtles is for effect of the bycatch. According to 93% of the interviewed the affectation is equal for all the heights and there is no species selection in the captures, but in the demand. While 96% distinguishes that the capture of olive ridley is more frequent, 4% mentions that is the black turtle. 78% prefer the consumption of the last one and says that they have better sale price. The juveniles <30 Ccl cm, are for self-consumption, the rest for selling on an illegal market of great demand in the region. 90% admit to have consumed sea turtle for opportunity, tradition or complement diet. The 30-year-old minor fishermen participants in the survey recognize that the fishing, in general, will stop being an economic profitable alternative in the immediate future. 100% admit to knowing the condition of risk and the legal measures for sea turtles, but they notice an insufficient or void vigilance in the zone for the application of laws. Therefore they admit that continuing affects these populations' risks as bycatch of commercial fishing.

## **SPEED SESSION 1**

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### **GREEN TURTLES IN THE EPARSE ISLANDS, SW INDIAN OCEAN: MITIGATED POPULATION STATUS BASED ON A 25 YEAR TREND OF DAILY TRACK COUNTS**

**Jérôme Bourjea<sup>1</sup>, Cyril Marmoex<sup>2</sup>, Marie Lauret-Stepler<sup>2</sup>, Francois Beudard<sup>2</sup>, and Stéphane Ciccione<sup>2</sup>**

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The green turtle, *Chelonia mydas*, is classified as endangered because of global declines over the past few centuries due to human exploitation and habitat destruction, particularly the loss of nesting areas. Using a smoothing spline ANOVA model, we used the number of tracks as an indicator of breeding female abundance at their nesting sites to update the trends of turtles breeding at 3 islands in the SW Indian Ocean (Europa, Tromelin and Grande Glorieuse) over 20 years. The long-term time specific data and the estimated underlying trend for Tromelin, Europa and Grande Glorieuse rookeries do not exhibit the same trend profile. Tromelin shows a clear and linear decrease since 1987 (Estimated linear track abundance growth rate = - 1.6%, 95CI= -1.8 – -1.3) and Europa shows a non strict linear increase since 1984 (1.6%; 95CI = 1.0 – 2.3). Grande Glorieuse shows a clear non linear increase since 1987 and the trend was divided into two sections one from 1987 to 1992 and the other one from 1992 to 2005. The increase was high at the beginning of the monitoring and slowed down to an estimated linear track growth rate of at 3.2% (95CI = 3.1 – 3.3) since the 90s. Even if the increase observed in Glorieuses and Europa is clearly due to protection over recent decades from human exploitation, the decrease observed in Tromelin could be due to a number of factors, such as fisheries and poaching in the east and north coast of Madagascar, which are their main foraging grounds, or local factors.

## **INTER-ANNUAL VARIATION IN MAGNITUDE OF BREEDING MAY MASK CLIMATE CHANGE IMPACTS IN MARINE TURTLES**

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We examine the change in phenology of nesting and hatching of two species of marine turtle (*Chelonia mydas* and *Caretta caretta*) over the past 16 years (1993-2008). The onset of both nesting and hatching of loggerhead turtles has become progressively earlier over this period. No such trend was recorded for green turtles, however, large nesting years were correlated to an earlier onset of nesting with a larger number of clutches laid by females in these years. We discuss the problems in detecting climate related trends in populations of non - annual breeders where large inter-annual variation in breeding occurs and investigate other potential indicators and drivers of climate change for these populations.

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## **TO EAT OR NOT TO EAT: SEA TURTLE CONSUMPTION IN THE BRITISH OVERSEAS TERRITORIES IN THE CARIBBEAN**

**Lisa M. Campbell<sup>1</sup> and Sue Ranger<sup>2</sup>**

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Consumptive and so-called non-consumptive uses of sea turtles coexist in many rural places where traditional coastal economies are transitioning to tourism based ones. This 'coexistence' is potentially problematic, as tourists wishing to view sea turtles nesting or in-water may not appreciate seeing them on restaurant menus or dinner plates. In this paper, we explore differing attitudes to sea turtle conservation and consumption among a variety of stakeholders interviewed in four British Overseas Territories in the Caribbean during 2002 and 2003 (Anguilla, British Virgin Islands, Montserrat, and Turks and Caicos Islands). Results from 291 surveys show surprising agreement between those associated with turtle consumption (e.g. fishers and consumers) and with tourism (e.g. dive operators, tour operators), most of who support the use of turtles as both a source of food and a tourist experience. We explore areas of agreement and disagreement among stakeholders, and the implications of such for sea turtle conservation.

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## **CONTEXT FOR MANAGING INDIGENOUS HUNTING IN AUSTRALIA**

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Under the Australian Government's Native Title Act 1993 Indigenous communities and individuals with a native title right (determined or common law) to hunt, gather, collect and fish or conduct a cultural or spiritual activity may do so for their personal, domestic or non-commercial communal needs without the permit or license required by non-Indigenous people, or Indigenous people who are not native title holders. Native title has its origins in, and is given its

context by, the traditional laws acknowledged and the traditional customs observed by the Indigenous inhabitants of a territory. The nature and incidents of native title must be ascertained as a matter of fact by reference to those laws. Native title rights may range from access and hunting rights to rights equivalent to exclusive possession, although in respect of 'sea country' the Australian High Court has determined that a native title right to exclusive possession would be contrary to the public rights to fish and navigate and the right of innocent passage. Indigenous harvest involves an extremely complex interaction of economic, social, and cultural factors, all of which need to be considered when managing the sustainable harvest of wildlife. For example, Indigenous harvest is important for maintaining family relations (kinship) and social structure, and has important ceremonial and community purposes and for some communities is also important in supplying food. Indigenous harvest of marine turtles and dugongs is generally managed through customary law. However in a number of Indigenous communities, changes in technology and the disruption of Indigenous culture are a growing challenge to this management. In addition, fluctuations in income of members of Indigenous communities may affect the intensity of subsistence harvest. Aware of the economic, cultural, and social factors that influence Indigenous harvest, the Australian Government's overarching policy is to ensure the conservation and protection of turtles and dugongs now and into the future for among other reasons, to ensure the continuation of the relationship between Indigenous peoples and these animals. It is vital that this management approach is developed and implemented in partnership with Traditional Owners and Indigenous communities; that it informs and provides support to Indigenous communities to sustainably manage turtles and dugongs in their sea country; and ensures that there will be robust populations of marine turtles and dugongs in the future to support a continuation of Indigenous harvest; as well as other broader beneficial environmental outcomes. A National Partnership Approach amongst Federal and State/Territory governments and Indigenous Traditional Owners is implementing these arrangements. Scientific information is used to inform discussions of sustainable levels of harvest in the context of all sources of human-related mortality as well as the social needs of the Indigenous communities.

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## **RAINE ISLAND: ISSUES AND IMPLICATIONS**

**Mark Hamann and Mariana Fuentes**

School of Earth & Environmental Sciences, James Cook University

Raine Island, a small coral cay in the northern Great Barrier Reef, is the most important rookery for the largest green turtle population in the world. This coupled with its global importance as a sea bird rookery and place of significant Australian indigenous and modern heritage makes it one of the most significant islands in Australia. However over the last decade research groups from the Queensland Parks and Wildlife Service have noticed declining nesting success of female turtles and consequently fewer hatchlings being produced. Several causes have been speculated, but not empirically tested. Among these are changes to the islands reef structure, hydrology and geomorphology. Needless to say the issue has become of interest to many sectors of community, especially Indigenous people in northern Australia and Government agencies. In 2006 with funding from the Australian Government we initiated a project to (1) investigate whether other islands for the green turtle population were showing similar declines in nesting success and hatchling production and (2) begin a population scale assessment on island geomorphology and climate change. At foraging areas we have found low juvenile recruitment into the population. At the other six main nesting beaches we have found that Raine Island is in the "middle" with regard to its vulnerability to climate change and that a detailed understanding of geomorphology is needed to understand reasons underlying poor nesting success. Importantly, our work with Torres Strait Islanders indicates that their access to turtles for cultural purposes could be extremely compromised should management intervention not be undertaken. In this talk I will provide an overview of the issue from the perspective of researchers interested in both species ecology and maintenance of livelihoods of Indigenous people. I will discuss the most recent data and research directions and consider the implications for Torres Strait Islanders and the short and long term implications for the green turtle population.

## **REASSESSMENT OF THE HISTORICAL DISTRIBUTION OF GREEN TURTLE HUNTING BY PAPUA NEW GUINEAN KIWAI HUNTERS IN TORRES STRAIT**

**Lauren Hess<sup>1</sup>, Mark Hamann<sup>2</sup>, Donna Kwan<sup>2</sup>, and Jillian Grayson<sup>2</sup>**

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An open access commercial fishery for hunted sea turtles and dugongs in the northern Torres Strait developed in the early 1970's. Concerns for the health of sea turtle and dugong populations caused the Papuan New Guinean (PNG) Minister for Environment and Conservation to provide legal protection for dugongs, but not sea turtles, through the Fauna Act of 1976. Hunting information and morphological data were collected from sea turtles and dugongs sold in the village of Daru in the late 1970's and early 1980's. Recent advances in technology, computing power and GIS software have enabled a spatial analysis of these data. The majority of the hunting was located in the northern reefs, with few trips reported in the northern Warrior Reefs. The average distance traveled by villagers selling their dugong captures in Daru was 22.7 kilometers with a range of 4.32 to 65.4 kilometers. Hunters' selling their turtle catches in Daru traveled up to 52 kilometers. Maps were created to show density of hunting per reef and to show connections of villages to reefs hunted. This analysis is important because of (1) growing concerns about the sustainability of the commercial market for sea turtles in Daru; (2) Torres Strait Islanders are concerned about PNG hunters hunting in their shared sea country for commercial markets and (3) where Kwan (1991) initially found few juvenile turtles in Daru, current anecdotal data from a variety of independent sources indicate more juveniles being sold.

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## **SURVEY TO DETERMINE INCIDENCES OF HUMAN FATALITY & ILLNESS FROM TURTLE MEAT CONSUMPTION IN THE UNITED REPUBLIC OF TANZANIA**

**Catharine Joynson-Hicks and John Mbugani**

Sea Sense, Dar es Salaam, Tanzania

Anecdotal reports from coastal communities in Tanzania suggest that human fatalities from consumption of turtle meat occur on an annual basis. However, details are unrecorded. The only incident that has been documented is from Pemba Island in 1997 when over 40 people died from eating a hawksbill turtle. In order to assess the level of threat to humans from turtle meat consumption and assess the uses of other turtle products, an interview survey was conducted in July 2008 in 10 coastal villages in mainland Tanzania. 252 people were interviewed, mostly male (90%). Almost half the respondents (46%) admitted to eating turtle meat, the most favoured and commonly available being the green turtle. Only 5 people had themselves become ill from eating turtle meat (green: 4; unknown: 1), suffering from stomach ache, vomiting and diarrhea. Many respondents (n: 191) were aware that turtle meat can be poisonous because flies avoid the carcass and the turtle blood, when touched, causes itching, and had heard of others who had suffered or died. Loggerhead turtles were cited as the most poisonous turtle, followed by green and hawksbill. Most reports of human deaths were between 1991 and 2000. Other turtle products commonly available include carapaces, used mostly as wall decoration, and oil which is used for cooking as well as medicine to cure asthma, ear ache and stomach ache.

## **CONSUMPTION OF MARINE TURTLES IN FIJI AND IMPACT ON HAWKSBILL AND GREEN TURTLE STOCKS IN THE WESTERN PACIFIC**

**Kenneth MacKay<sup>1</sup>, Merewalesi Laveti<sup>2</sup>, and Neema Nand<sup>3</sup>**

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Nesting populations of marine turtle in Fiji appear to be very low with estimates of less than 50 green and 150 hawksbills nesting annually. There has been little long term monitoring, all indications including limited beach surveys and anecdotal information, suggest a substantial decline in nesting populations in the last 20-30 years. Based on various tagging studies most of the green turtles found foraging on the extensive sea grass beds of Fiji may nest to the east of Fiji in Polynesia particularly in American Samoa and French Polynesia. While recent satellite tagging studies suggest that hawksbills nesting in Fiji may be more resident and stay within Fijian waters. Fiji has an official turtle harvesting moratorium which has an exemption for traditional purposes upon application to the Minister of Fisheries. However, the moratorium is not enforced and appears to be ineffectual. Turtles are important to Fijian coastal villagers as a source of food where both greens and hawksbills are captured incidentally during other fishing activities. Marine turtles are also revered chiefly for traditional purposes where they are captured by traditional fishing clans (the Gonedau) often using special large mesh nets. Large turtles, primarily green, are prized for these events. This paper will report on an analysis of size and species composition from data collected over the past 20 years to make suggestions on the possible impacts of both the subsistence and traditional activities on Fijian and regional turtle stocks.

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## **THE ROLE OF EXTERNAL CALCIUM CARBONATE IN LOGGERHEAD TURTLE NEST INCUBATION**

**Mario J. Mota and Ray R. Carthy**

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The media surrounding a sea turtle clutch has a paramount influence on its incubation and development. Beach properties such as sand compactness, water potential, and grain size composition are important factors that have the potential to hinder or support embryogenesis and hatching success. Another similarly important sand physical characteristic is its concentration of calcium carbonate. High concentrations of  $\text{CaCO}_3$  can increase sand compactness that may restrict gas diffusion between the clutch and atmosphere as well as hamper hatching emergence. Low  $\text{CaCO}_3$  concentrations are also undesirable because carbonate is an important factor in maintaining nest chamber integrity and a possible calcium source for developing embryos. This project examines the influence that the concentration of total unbounded  $\text{CaCO}_3$  in sand has on the concentrations of carbon dioxide in incubating loggerhead sea turtle nests. A total of 320 eggs collected from 6 different nests were randomly assigned to 8 experimental incubators. The experiment was designed with two sand treatments of low (3.11%) and high (10.74%)  $\text{CaCO}_3$  concentrations, collected from native and renourished beaches, respectively. The incubators were housed in a chamber whose light cycle, temperature and humidity were regulated. A control group of 4 additional incubators were buried on the native beach, and additional in situ sea turtle nests were monitored. The beach incubators replicated experimental conditions except that their bottoms were removed to prevent rain water from pooling and drowning the clutch. Air samples extracted weekly from the incubators and in situ nests were analyzed for  $\text{CO}_2$  and  $\text{O}_2$  using gas chromatography. Oxygen concentrations were used to validate the cycles observed in  $\text{CO}_2$ . Data from each treatment group were averaged and trend lines plotted. An ANOVA tested for significant differences ( $P < 0.05$ ) between treatment groups and the Bonferroni test was used to identify post hoc differences. Results indicated no statistically significant differences between the  $\text{CO}_2$  concentrations of the in situ beach nests, the control beach incubators and the experimental native sand incubators. However, the  $\text{CO}_2$  levels from the incubators with the high  $\text{CaCO}_3$  concentration (renourished sand) were significantly different from the in situ beach nests and the control beach incubators. Our earlier work has shown that the  $\text{CO}_2$  concentrations from nests in renourished sand are typically higher than those from nests in the native beach. This is attributed to a corresponding

increase in sand compactness that can lower hatching success. We hypothesize that the higher concentrations of unbounded carbonate buffered the detrimental effects of  $\text{CO}_2$ . Analyses of the post incubation sand showed that the incubators with renourished sand lost approximately 50% more  $\text{CaCO}_3$  than those with native sand. We conclude that an increase in unbound and low-reacting  $\text{CaCO}_3$  in renourished beach sand can help incubation by preventing the concentration of high  $\text{CO}_2$ . However, carbonate content must be carefully regulated because very high concentrations can negatively impact sea turtle nesting ecology by increasing cementation and preventing hatchling emergence.

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## **COMPARING NESTING STRATEGIES OF LOGGERHEAD AND LEATHERBACK TURTLES IN SA: DOES EQUAL CONSERVATION EFFORT MEAN EQUAL RECOVERY POTENTIAL?**

**Ronel Nel**

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Loggerhead and leatherback turtles use the beaches of northern KwaZulu-Natal (South Africa) and Southern Mozambique to nest, and both species have been under pressure for egg and female harvesting in both countries at the turn of the previous century. In 1963 the active protection and monitoring of sea turtles started in South Africa after the numbers of nesting females were noticeably suppressed. The same action was not instigated in Southern Mozambique until three decades later (1996). In South Africa, however both species responded, immediately and positively to the nest protection and for the first decade numbers of both species increased. Leatherbacks increased from 36 – ca.60 nests in the index area, and loggerheads from ~ 300 to 700 nests in the index area. Then however, leatherback numbers stabilised while the loggerhead numbers continued to increase and are now more than 1700 nest per annum in the index area. Loggerhead numbers are still increasing while leatherback numbers, despite identical conservation effort is fluctuating but stable at still 60 nests (in the index area). A comparison of the life history suggests at least equal, or even increased recovery potential for leatherbacks in comparison to loggerheads as a response to the higher reproductive output. The 4-plus decades of monitoring indicates a nesting interval for leatherbacks to be 9-10 days, laying ~110 eggs at a time and laying between 7-8 times in a season. Loggerhead turtles on the other hand nest every 14-15 days and nesting only 3-4 times in a season, with about ~100 eggs. Loggerheads are more skittish and will nest only ½ of the time while leatherbacks will nest 9 out of ten times. Both species have a mean remigration period of ~ 3 years. Through notching experiments the time to maturity for loggerheads have been indicated at ~22 years (for South Africa) while this is assumed to be less for leatherbacks. The greatest difference in nesting strategy for these two species is nest fidelity and specificity in nest location. About 300km of sandy beach is available for nesting to these species, of which there is no harvesting in the 200km in South Africa. Leatherback turtles tend to nest over the entire area, all within the same season. Loggerhead turtles on the other hand are much more specific. Around 50% of the population nest only in ~ 8km of the entire 300km. The rest of the nesting is spread evenly. An evaluation of bycatch information indicates that both species are caught at a ratio similar to their abundance. The only possible explanation for the stability (instead of recovery) of leatherback numbers is that the South African beaches may be predominantly male-producing beaches. An incubation temperature study seems to support this hypothesis but this needs to be replicated over more seasons and a greater part of the nesting area before it could be accepted as a possible explanation for the disparate recovery rates.

## **TRACKS COUNTS: A USEFUL TOOL FOR MONITORING TEMPORAL AND SPATIAL TRENDS IN SEA TURTLE NESTING ACTIVITY AND POTENTIAL IMPACTS FROM INDUSTRY**

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Reliable estimates of sea turtle abundance are essential for diagnosing long-term population trends, assessment of sustainable use options, exploring the potential impact of climate change and the evaluation of species recovery strategies. Most assessments of sea turtle population trends have been based on long-term monitoring of the seasonal beach nesting activity of adult females. Usually, the nesting activity is measured as either number of tagged nesting females or the number of nests counted. When undertaking assessments of sea turtle populations for industrial and resource development in the north-west of Western Australia these measures are not always possible due to a range of logistical constraints including costs, resources and scheduling for regulatory approvals. In these cases a commonly used proxy measure of nesting activity is the number of turtle tracks counted each morning on a beach during the nesting season. Whether track counts are a valid proxy measure of nesting activity has never been robustly evaluated and there is an urgent need to do so. Here we explore the utility of using track counts as an informative proxy for nesting activity on Barrow Island, 50km off the mainland coast in the Pilbara region, where there are substantial flatback and green turtle nesting populations. We used a nonparametric regression modeling approach to estimate temporal and spatial trends in flatback and green turtle nesting activity at seven flatback and eight green turtle nesting beaches on Barrow Island over a 5-year period from 2004-2008. We found that daily track counts on Barrow Island is a useful proxy measure of nesting activity for low-to-medium nesting (70 tracks per day). The track counts showed that the peak flatback and green turtle nesting seasons occurred during December-January. Flatback nesting activity measured using track counts suggested a significant increasing trend since 2004 but this was not apparent using nest counts. Green turtle nesting activity using track or nest counts both suggested a significant nonlinear trend with increasing nesting activity until 2006 and then a recent gradual decline. We also found significant variation in either track or nest counts between the various nesting beaches for both species. This baseline information allows industry to improve their planning and management of their operations and to monitor the potential impacts on sea turtle nesting activity. In conclusion, using tracks counts is a useful tool for monitoring temporal and spatial trends but need to be used with caution and is no substitute for a comprehensive capture-mark-recapture program for monitoring Barrow Island sea turtles.

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## **ANNUAL SURVIVAL OF NESTING LOGGERHEADS IN THE NORTHWEST ATLANTIC OCEAN**

**Christopher R. Sasso<sup>1</sup>, Llewellyn Ehrhart<sup>2</sup>, Michael Frick<sup>3</sup>, William Redfoot<sup>2</sup>, Kristina Williams<sup>3</sup>, and Julio Zurita<sup>4</sup>**

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Annual survival rates were estimated using tagging data from Melbourne Beach (FL, USA), Quintana Roo (Mexico), and Wassaw Island (GA, USA) using a multi-state model with separately identifiable survival and capture probabilities. Survival estimates were generated which allowed individuals to transition between an observable breeder state and an unobservable non-breeder state. Using these methods, individuals could temporarily emigrate, spend multiple years in a non-breeder state, and transients could be accounted for in the analyses. The number of years spent in the non-breeder state was constrained by the number of years being tested for the breeding cycle with cycles of 2, 3, 4 and 5 years tested here where the cycle length is defined as the number of years skipped between nesting plus one as a breeder. The best of the candidate models for each nesting area was selected using the quasi-likelihood Akaike Information Criterion. The survival rates calculated by the model for each group (transients and residents) allow for an unbiased estimate of the proportion of transients in the data. Survival rates were time invariant and ranged from 0.73 to 0.85 while the proportion of transients ranged from 35% to 69% for the three beaches. The results generated here suggest that survival may be lower for Melbourne Beach nesters. However, the data from Melbourne does not represent a dedicated mark-recapture study and the analysis based on these data may be an underestimate of true survival. Further research will be necessary to determine if adult female survival is lower for the Peninsular Florida subpopulation and a potential cause for the rapid decline in nesting numbers.

## **SPEED SESSION 2**

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### **POPULATION STRUCTURE AND USE OF A NEWLY IDENTIFIED FORAGING GROUND IN THE SOUTH CARIBBEAN COAST OF COSTA RICA**

**Joana M. Hancock and Didiher Chacon**

WIDECASST Latin American program, Heredia, Costa Rica

Research on the sea turtle foraging grounds at Cahuita National Park (09°44'05.1"N, 82°48'36.0"W), in the South Caribbean coast of Costa Rica, was carried out between September 1st and October 31st, 2005-2007. In addition to the continuation of the monitoring and tagging efforts first developed in Cahuita National Park in 2003, the research focused on the observation of turtles by snorkeling and scuba diving in established monitoring stations and the habitat characterization and capture of sea turtles to study their biometrics. The most common capture method was the use of entanglement nets. The dimensions of the nets used varied between 60-70 m length and 6-7 m depth, with a mesh size of 25 or 45 cm. The nets were left for various periods each time and checked 2-3 times a day. Hand captures were attempted whenever possible during the in-water surveys. The total net exposure time in 2007 was 1,029 hours, resulting in 26 captures, with a recorded CPUE of 0.54 ind/24h. Three sea turtle species were captured: *C. mydas* (n=18, plus three recaptures), *E. imbricata* (n=2) and *C. caretta* (n=2, plus two recaptures). Only 27% of the total captures of *C. mydas* between 2005 and 2007 were adults, while 15.7% were under 40 cm. The sizes of captured *E. imbricata* were 58.0 and 69.7 cm CCL and *C. caretta* were 76.2 and 80.1 cm CCL. A total of 2,725 minutes (45.4 h) were spent in in-water surveys, resulting in the observation of 32 turtles (CPUE = 0.70 ind/h, range 0-1.32 ind/h). The species sighted were *E. imbricata* (53%) and *C. mydas* (25%), the remaining were unidentified species (17%). The

turtles were juveniles (estimated less than 80 cm carapace length) on 87.5% of the sightings. Results from this season indicate that there are animals with the minimum recruitment sizes to the coastal areas. This has been documented before for *E. imbricata*, but not for *C. mydas*. It is essential that the monitoring and tagging efforts continue to better understand the presence of different size classes of these species (including *Caretta caretta*), the role of the animals in the reef, and the use of the different habitats studied.

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## COMMUNITY CONSERVATION: A NOVEL APPROACH IN THE SRI LANKAN SEA TURTLE CONSERVATION SCENARIO

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Five out of seven species of endangered sea turtles nest in Sri Lanka including critically endangered leatherback and hawksbill turtles. Destruction of their ecosystem by local communities is a serious problem in Sri Lanka. As a result, key coastal habitats and fauna such as the coral reefs, sea grass beds, mangroves and thus are under serious threat. Turtle Conservation Project (TCP) established in 1993 with the aim of marine turtle conservation, realized the interdependent links between coastal communities and marine resources and the need to conserve them through community based ecosystem conservation approaches (CBECA). Rekawa, Kosgoda and Kalpitiya are three Sri Lankan fishing hamlets that have had heavy dependence on their coastal marine resources, while faced with issues of poverty and lack of awareness. In collaboration with international, national and local partners and through a multi-pronged CBECA approach of several components: 1). community livelihood development, 2). community infrastructure development, 3). environmental restoration and management, 4). community awareness/capacity building, 5). community partnership and network building, 6). knowledge management & sharing (Current & traditional knowledge), 7). utilization of local culture, TCP has changed the tide towards sea turtle conservation. Alternate livelihood assistance has included forming of community based organizations (CBO)/ groups for Batik production, fish breeding, sewing, coir mat making, bee keeping, agro farming, mangrove nursery development, crab cultivation, and other forms of alternate livelihood development including the imparting of skills and training for these CBO members. Impetus for growth of livelihood options has been nurtured with equipment, raw materials, or injection of funds through revolving credit schemes. Infrastructure development such as renovation of rural roads in order to facilitate local tourism and other businesses has been another avenue of community support. In addition, TCP has established a public library, public bus stop shelters, and drinking water facilities. Further, TCP has also implemented programs in skill development, community health and education. The TCP developed multiple partnerships in order to make these projects a success. TCP facilitated networking of CBOs into an umbrella organization/consortium of CBOs. Later this was linked to relevant government institutions, local business organizations, and international partner organizations such as Marine Conservation Society (MCS), UNDP GEF SGP, UN Volunteer Program, SCOTIA - USAID, International Fund for Animal Welfare (IFAW) and MercyCorps, for necessary training, business linkages and marketing opportunities Eg. SCOTIA-USAID helped finance a Batik production facility in Rekawa. Mercy Corps helped both the Batik and Coir Groups by financing for kiosks for display and sale of community products. IFAW has helped support the employment of egg poachers as nest protectors and in educating fisherfolk on sea turtle disentanglement. While socioeconomic conditions and the well being of the communities have been improved, so has the extent of sea turtle nesting habitat for protection and cooperation for active sea turtle disentanglement from fishing nets. The Wildlife Conservation Department has supported the activities and has been involved in enforcing the law and further strengthening it by helping create Sri Lanka's first Marine Turtle Sanctuary in Rekawa.

## **HORIZONTAL TRANSFER TO CHANGE FISHERS' CULTURES AND ATTITUDES ON TURTLE BYCATCH - THOUGHTS AND OPINIONS OF A COMMERCIAL FISHER**

**David Kreutz**

Belldi Consultancy

The 'conventional' methods of marine turtle bycatch mitigation generally involved considering a commercial fishing fleet as a single entity with individuals found guilty of 'bycatch-crimes by association', often without proof that they have personally impacted the animals of concern. If it was shown, or believed, that at least one vessel in the fleet caught marine turtles or other threatened, endangered or protected species then restrictions and conditions were imposed on all vessels and often on all fishing grounds. These can include compulsory restrictions on fishing effort or catches, adoption of stringent management regimes including questionable mitigation measures and devices, and extensive and expensive monitoring and compliance programs. More often than not these measures haven't achieved the expected results. The measures seemed good in theory, but unworkable in practice. Is there a better way? Yes, there is. It involves an approach of changing individual fisher attitudes and providing them with the ability, tools, support and, most importantly, the inclination to deal with their own problems. It is a modification from the generally used top-down decisions (for example, information transfer from managers with advice from scientists to fishers) to horizontal transfer of knowledge across the fleet (for example, managers, scientists and fishers within a fleet working as a team and also using leader-fishers as mentors). It became clear to me after 20 years as a commercial longline fisherman and accepting some foolish management decisions and also becoming involved in mitigation research projects, that we all must change our approaches and attitudes if we are to succeed in making a difference.

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## **THE USE OF COMMUNITY "CONSERVATION DEEDS" AS A TOOL TO MANAGE MARINE CONSERVATION AREAS**

**Wenceslaus Magun**

Sea Turtle Restoration Project & Bismarck Solomon Seas Indigenous Peoples Council, Pt. Moresby, National Capital District, Papua New Guinea

The Protected Area legislation existing now in Papua New Guinea is viewed as a major obstacle in the creation and effective management of Protected Areas in the country. There appear to be many bureaucratic processes that either hinder or delay the establishment of Protected Areas in both marine and terrestrial areas. Conservation Deed is guided by the Common Law, Principles of Contract and is subject to the Laws of the Independent State of Papua New Guinea. It binds all who identify themselves with the Clans mentioned in the Deed and can be upheld in any Court of Law in PNG. This has resulted in indigenous communities taking a further step in creating innovative tools that will greatly simplify the establishment of areas intended to be set aside for various purposes whether for recreation, scientific research, conservation or sustainable use of resources. Aside from this, ultimate power is given to the locals to design, plan and control the areas earmarked for this purpose. The Conservation Deed is now deemed to be a powerful tool that locals can use to customize and implement projects to fit into their culture to reduce conflict with any planned or predetermined land uses. It also ensures that cultural links, whether individual or through clanship ties, are unaffected. It is regarded as powerful because it can be upheld in a Court of Law and is enforceable against those that are bound by the Deed or have executed the Deed. Implementation and enforcement would occur through the terms and Conditions of the Deed. Specified protections and standards would be maintained within at all times, so as to give it the intended effect, which is to be bound and enforced through Principles of Contract. The Conservation Deed tool is currently being used by more than 3,000 indigenous peoples of the north coast region of the Madang Province in PNG to manage their resources, and more particularly use their resources at sustainable levels. Six Conservation Deeds protecting leatherback beaches and marine habitat as well as coral reefs, riparian areas and fishing grounds are now being adopted and implemented. The concept will be used in other coastal and marine communities throughout the Western Pacific Region. In summary, the Conservation Deed is considered an effective tool that community resource owners can use to

help prevent land tenure conflicts and promote sustainable use of natural resources. The Deed takes into account the local culture and is flexible in its approach, provided that terms and conditions are maintained to reflect principles of the Conservation Deed Contract.

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## **TURTLE DEATHS AT SEA UNDERMINE PROTECTION MEASURES ON NESTING AREAS IN WESTERN PELOPONNESUS AND ZAKYNTHOS, GREECE**

**Aliki Panagopoulou, Paul Tsaros, and Dimitris Margaritoulis**

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The most important loggerhead nesting areas in Greece are found in Laganas Bay on Zakynthos Island and Kyparissia Bay in western Peloponnesus. These two areas, lying 70 km apart, host 63% of all loggerhead nests made annually in Greece and 37% of the ones documented in the entire Mediterranean. Concerning conservation, Laganas Bay enjoys protection measures by means of a National Marine Park. Kyparissia Bay contains a diversity of natural, anthropogenic and archaeological features, which have stemmed the designation of four NATURA 2000 sites (a European Union Network of protected areas). ARCHELON has been running conservation projects in both these areas since 1983, collaborating with the National Marine Park of Zakynthos since its establishment in 1999, and compiled in 2002 a Special Environmental Study and Management Plan for Southern Kyparissia Bay, a prerequisite to provide the area with specific protective legislation. While ongoing conservation efforts in these areas date 25 years, during the last decade a significant increase in sea turtles reported dead has been observed. From 1998 to 2007, 305 turtles have been found dead along the coastline south of Cape Killini in western Peloponnesus and on Zakynthos, representing 17.3% of the totals for Greece. In 2007 alone, 55 turtles were reported dead in this region, representing 23.1% of the annual total for Greece, while 2008 seems to be close to these numbers since by 15 August 31 strandings have already been reported. Most of these 305 dead turtles were loggerheads, except for 2 green turtles and 9 where the species was not identified. 102 were adult females (of which 19 were tagged by ARCHELON while nesting in Kyparissia Bay or Zakynthos), 80 adult males while for 123 the sex was not determined either because the carcass was too decomposed or because the turtle was still immature. Measurements taken from 256 of these turtles also reveal that 173 (67.6%) have CCL  $\geq$  65cm, 60 have  $65 \text{ cm} \geq \text{CCL} \geq 50 \text{ cm}$  (23.4%) and the remaining 23 (9%) are between 30 and 45 cm in length (CCL). The marine area off Western Peloponnesus and Zakynthos is frequently used as fishing grounds for trawlers registered in the nearby ports of Patras and Killini, as well as swordfish long liners and artisanal fisheries. Therefore there are increased fisheries interactions with sea turtles in this region, which can account for the increased mortality at sea. The situation is further aggravated if we take into account that this mortality at sea in the region involves mostly adult or sub-adult individuals (male and female) which can ultimately affect the nesting colonies on both Zakynthos and Kyparissia Bay. As a result, it is of the utmost importance that efforts should focus on protecting turtles at sea by mitigating the impact of fisheries – otherwise there is a strong possibility that conservation efforts on these important nesting sites will be rendered invalid. Acknowledgements: The authors wish to thank Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation for financial support that made it possible for AP to attend the Symposium.

## **THE USE OF DEVELOPMENT INCENTIVES TO PROMOTE BUY-IN AMONGST LOCAL COMMUNITIES FOR TURTLE CONSERVATION IN PAPUA NEW GUINEA**

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Natural resources are under the jurisdiction of local communities in Papua New Guinea, and marine turtles, particularly the endangered leatherback, are no exception. The Marine Research Foundation has implemented a sea turtle research and conservation project along the Huon coast in PNG on behalf of the Western Pacific Regional Fisheries Management Council since 2004, in collaboration with the PNG Government and several local NGOs. The project today involves seven villages, with a coordinator from each of those villages maintaining communication and coordination links with project management. Through the coordinator, representatives of each of the clans in each community are assigned to beach patrol duties for which they receive a daily salary. Beach monitors conduct morning track counts, install protective bamboo grids over nests to deter feral dog predation, or work at night to deter poaching while tagging and recording the nesting activity of adult females. During the initial years, significant conflicts arose amongst the local communities and also between the communities and the project team over cash incentives and inevitable limitations on the numbers of local villagers who could participate in the project. Increases in manpower never alleviated the problem, and indeed created newer ones with higher cash flow requirements and even greater community-based conflicts of cash payouts. In 2006, the turtle project developed and implemented a novel community development incentive programme, whereby funds were allocated to each village for development purposes through which cash was not disbursed, rather goods and services were paid for directly from project funds. The rationale behind the incentives was to be able to provide tangible benefits to every member of the community even though they may not have directly benefited from cash payments through beach patrols. These development incentives have taken the form of new furniture for one community's school, a new church building in another, relief supplies following conflict and strife, and materials to complete construction of a school building. The communities decide how they would like to spend the funds, in a way which benefits the largest proportion of the village, and the turtle project management takes care of the rest. The development projects are carried out as collaborative efforts, whereby all members of the community and the turtle project come together to fix, repair, build or transport in the name of the community. When the "development incentive" concept was explained to villagers, we stressed that the idea was that each time they passed the new school classroom, or the repaired aid outpost, or sat in church on Sunday, they should thank the turtles themselves, not the project or its management, as these were the resources which had brought benefits to the people. While this aspect of the project has had its ups and down, it is slowly becoming a mainstay of the programme, as communities see greater benefits than cash for being involved in conservation of the endangered leatherback turtle in PNG.

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## **THE MANAGEMENT OF MARINE TURTLES WITHIN THE GREAT BARRIER REEF MARINE PARK**

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The Great Barrier Reef Marine Park (GBRMP) extends along the northeast coast of Queensland and covers almost 350,000 kms<sup>2</sup> in area and is managed by the Great Barrier Reef Marine Park Authority (GBRMPA). Six species of marine turtle are recorded from the Marine Park and the area contains internationally significant nesting and foraging populations of green, loggerhead, hawksbill and flatback turtles. Olive ridley and leatherback turtles are rarely encountered in the marine park. The GBRMPA has implemented a range of management tools within the Marine Park

(primarily legislative and strategic policy framework) to ensure the conservation and ecologically sustainable use of marine turtles. The GBRMPA has also utilised risk-assessment methodologies to identify high priority species. In consultation with the GBRMPA, external research providers have developed and implemented targeted research and monitoring programs to allow the GBRMPA to make informed management decisions.

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## **LONG-TERM TRENDS IN BASKING HAWAIIAN GREEN SEA TURTLES IN THE NORTHWESTERN HAWAIIAN ISLANDS**

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In general, very little information exists regarding trends for sea turtle populations at any stage other than nesting adult females, and this lack of information hampers population assessments. Hawaiian green turtles exhibit a basking behavior where juveniles and adults emerge from the water to rest on beaches. This behavior allows for unique estimates of abundance to be made on life stages other than adult females. The main rookery for Hawaiian green turtles is at French Frigate Shoals (FFS) in the Northwestern Hawaiian Islands (NWHI) where over 90% of nesting in the Hawaiian Archipelago takes place. From 1983 to present, the Marine Mammal Research Program at the Pacific Islands Fisheries Science Center has been monitoring the Hawaiian monk seal population at six main sites within the NWHI. Despite the project's focus on monk seals, data were also collected on green turtles observed basking at FFS, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Atoll, and Kure, including information on size class and sex for adults. We were able to validate that annual numbers of turtles observed basking were proportional to the abundance and size distributions found in the water by comparing them to other datasets including nesting female counts at FFS and size distributions of in-water juveniles at Midway. Analyses of these data has provided unique information on changes in the proportions of the different size classes observed basking, relative abundances for these size classes through time, and sex ratios of adults. We found that the sex ratio of adult females to males at FFS varied with numbers of nesting females: in years with high nesting, there were higher proportions of females basking while in low nesting years there were lower proportions of females basking. This suggests that there may be a relatively constant number of males migrating to the breeding grounds. We also found evidence of movement of juveniles between Laysan, Lisianski, Pearl and Hermes, and Midway suggesting connectivity between these foraging areas. Together this information will improve our ability to assess and monitor the status of the Hawaiian green sea turtle population.

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## **THE INTRODUCTION OF TURTLE EXCLUDER DEVICES IN SHRIMP TRAWL NETS AND SEA TURTLE CONSERVATION STRATEGIES IN SMALL SCALE FISHERIES IN THE SOUTHERN GULF OF GUINEA**

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Turtle Excluder Devices (TEDs) are installed in shrimp trawl nets as a management tool to reduce fishery related sea turtle mortality. This is a critical component of sea turtle recovery efforts world wide. In shrimp trawling for every kilogram of shrimp caught up to 20kg or more of other fish are inadvertently captured and killed. The activities of the Global Environment Facility (GEF), United Nations Environmental Programmes (UNEP)/Food and Agriculture Organization of the United Nations (FAO) include the installation and proper use of TEDs to mitigate the problem of sea turtle incidental catch and at the same time ensure that there is no drastic reduction in the quantity of shrimps. The certification of Nigeria for TED compliance and permission to sell all categories of shrimps to USA markets rekindled the interest of the Fishing Industry in Cameroon, Togo, Republic of Benin, Gabon and Sao- Tome & Principe on TED

development and adoption in order to enjoy the same opportunity and benefit of higher prices for shrimp export. Therefore capacity building on TED construction and harmonization of the fisheries laws and regulations were stepped up in order to facilitate uniform regime of application and enforcement in the sub region. The report highlights conservation strategies for small scale artisanal/traditional fisheries which also account for a large number of sea turtle mortality in the sub-region.

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## **PATOKU: MONITORING AN IMPORTANT SEA TURTLE FORAGING GROUND IN ALBANIA**

**Michael White<sup>1</sup>, Idriz Haxhiu<sup>2</sup>, Enerit Saçdanaku<sup>3</sup>, Lazion Petritaj<sup>3</sup>, Merita Rumano<sup>4</sup>, Prue Robinson<sup>5</sup>, Stephanos Kouris<sup>5</sup>, and Lily Venizelos<sup>5</sup>**

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Turtles have been tagged in Albania since 2002. The coastal distribution patterns of turtles were surveyed in 2005, and fishermen throughout Albania were interviewed. There are many loggerheads in Albania's northern-most bay at Patoku: the shallow habitat is sand/mud, rich in molluscs and crustaceans, and marine plant-life is sparse as underwater visibility is mostly poor. Researchers are investigating whether this habitat supports summer-only or year-round foraging, mating, development, overwintering, or transient use by migrating turtles. Artisanal-fishing is the main economic activity in this remote area and turtles are caught as bycatch. Dynamite-fishing is a particular problem at Ishmit, Tales and Shengjin, but policing resources are extremely limited. Stavnikes are large rectangular fish-traps constructed of posts and nets, usually set in shallow seawater (5-6 m depth) and emptied each morning by boat. A barrier-net, which guides fish into the stavnike, extends from the trap towards the beach. Although there were 18 stavnikes throughout the bay, only two fish-traps, near to Ishmit and Matit Rivers, were monitored closely. Other fishermen were interviewed whenever possible. The Ishmit and Matit fishermen captured 126 turtles in their stavnikes (June-July). Photographic-recognition and morphometric data were collected, health status was assessed, and turtles were tagged and released. Most turtles (80%) were large short-tailed loggerheads (mean CCL=65 cm; n=98). There was only one adult female; however, this was also the egg-laying period in the Mediterranean region and perhaps adult females will be encountered later in the year (post-nesting). The distribution and lifestyle of male turtles are not as well known as that of females. Patoku may be a male foraging and developmental habitat, as 20% of loggerheads tagged in June were males (adult=4; adolescent=9). This is important because of the potential feminizing effect of climate change on global turtle populations. A juvenile green turtle, *Chelonia mydas*, (CCL 39 cm) was in Ishmit stavnike (June). Regionally this species nests only in the northeastern Mediterranean. An important result of this study was that entrapped turtles were not deterred from foraging locally, despite being manhandled out of the nets and landed for measuring and tagging. The evidence for this is that 17 recently-tagged turtles were recaptured in stavnikes on more than one occasion (one was taken five times, two were taken three times, and 14 were captured twice). These serial recaptures indicate that at least some turtles showed short-term fidelity to Patoku's foraging grounds (16 *Caretta caretta* and the *Chelonia mydas*). Some turtles (6 *Cc* & 1 *Cm*) were captured in both stavnikes (4.5km apart), suggesting a larger foraging area was being used, whereas the other recaptures were always in the same traps. Stavnikes appear to be a turtle-friendly method of fishing. Perhaps the most important factor is that turtles entering the traps can swim around and surface to breathe. Ten loggerheads had been tagged in previous years (all at Patoku since 2003), which indicates repeat migrations, either to Patoku or en route elsewhere.

## **SEA TURTLE CONSERVATION IN BALI – INDONESIA, SOCIAL – CULTURAL, EDUCATION, PRESS AND LAW ENFORCEMENT APPROACH**

**I Wayan Wiradnyana**

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The Indonesian archipelago is home to 6 out of 7 of the world's sea turtles species, including; green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), leatherback turtle (*Dermochelys coriacea*), olive ridley turtle (*Lepidochelys olivacea*), loggerhead turtle (*Caretta caretta*) and flatback turtle (*Natator depressus*). Indonesia has numerous islands as places for nesting and foraging areas for sea turtles. Bali is one of these island. Bali has become a major area for ProFauna campaigns, as sea turtle consumption is large scale here. Based on the Indonesian State's Legislation no.5 of 1990 on Conservation of Natural Resources and Ecosystems and the Government's regulation no.7 of 1999, all turtles in Indonesian seas are protected. The trade of turtles and their body parts in therefore prohibited. Despite the fact that all sea turtle species in Indonesian waters are already protected by Indonesian law, illegal trade of sea turtles and their parts still occurs. Sea turtles in Indonesia are exploited for their meat and eggs for consumption, carapace for souvenirs and turtle oil for traditional medicine. Every year thousands of sea turtles are captured to meet the trade demand. Based on ProFauna Indonesia investigation on 1999 there are more than 27,000 alive green sea turtle being slaughtered in Bali for meat consumption. ProFauna has been campaigning for turtle protection in Bali since 1999. The campaign was conducted by several approaches: (1) social culture, (2) community education, (3) press, and (4) law enforcement. Social culture is important for the campaign as Balinese are mostly Hindu who have rituals ceremony using animals including turtles. The campaign was conducted involving the Hindu priest who agreed to replace turtles with other mean including farm animals or symbols. ProFauna has a regular visit program to schools and community to raise the issue among the community. Press is a crucial part of the campaign to increase awareness and also to put pressure on government to uphold the law. ProFauna campaigns by conducting attractive and unique protests that invited press to report. Law enforcement by the authoritative government body is the target after the investigation and campaign activities. The result of the campaign shown on 2001, many confiscations to enforce the law were conducted. Number of turtle trade drastically decreased because of positive impact of confiscation programs held by the police department of Bali. Based on ProFauna's monitor in 2004, the trade of green turtle has decreased to 3,000. Nowadays, sea turtle trade is still found on Bali but in very low numbers and only on the black market. Along with the increase of public understanding on sea turtle protection in Bali, local people in several villages have actively protected turtles that laid on the beach and their eggs. This program is a collaboration between ProFauna, Forestry Dept. and local communities at Kuta beach and Klungkung regency.

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## **SAVING THE MARINE TURTLES - THE MEKAR EXPERIENCE**

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Threats to marine turtles are mainly anthropogenic in nature such as turtle egg consumption, use of non-turtle friendly fishing devices, boat collision, pollution and destruction of marine turtle foraging and nesting habitats. For any turtle conservation initiative to be successful, these anthropogenic threats must be also arrested. One of the best approaches in which this can be done is by collaborating with the local community who live near the nesting beaches. In Terengganu, Malaysia, the local community of Paka-Kerteh-Kemasek, a cluster of three different districts, have for the past three years been actively involved in community based turtle conservation through a community-based organisation they set up, called MEKAR. MEKAR's strategy has been in creating awareness and capacity building the local community through community outreach, public awareness and training activities. MEKAR's the long term objective is to create a community that is well informed and equipped with the necessary knowledge and skills to make the necessary behavioural and lifestyle changes that can impact positively to turtle conservation initiatives in the area. With increased experience, knowledge and skills MEKAR will be able to participate in community based turtle sanctuary management with other relevant stakeholders. This paper shares the MEKAR experience, its trials, tribulations and success stories,

and hopes to impress the importance of community involvement in ensuring the success of turtle conservation initiatives. Acknowledgement: International Sea Turtle Symposium, Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, US. National Marine Fisheries Service, and the U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund).

### **SPEED SESSION 3**

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## **FORAGING DESTINATIONS AND HIGH-USE AREAS OF WESTERN PACIFIC LEATHERBACK TURTLES**

**Scott Benson<sup>1</sup>, Peter H. Dutton<sup>2</sup>, Creusa Hitipeuw<sup>3</sup>, Betuel Samber<sup>4</sup>, Ricardo Tapilatu<sup>5</sup>, Vagi Rei<sup>6</sup>, Levi Ambio<sup>7</sup>, John Pita<sup>8</sup>, Peter Ramohia<sup>8</sup>, Joe Horoku<sup>9</sup>, Tomo Eguchi<sup>2</sup>, and Barbara Block<sup>10</sup>**

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Endangered Western Pacific leatherback sea turtles, *Dermochelys coriacea*, form an ecologically diverse metapopulation, which forages in several tropical and temperate regions of the Pacific and Indo-Pacific region. Multi-year satellite telemetry studies at Bird's Head Peninsula, Papua Barat, Indonesia; Huon Gulf, Papua New Guinea; and Santa Isabel Island, Solomon Islands have revealed variations in migratory routes and foraging destinations, and links to oceanographic processes. The most apparent pattern in this dataset (n=91) is a clear separation of migratory destinations for boreal summer (July) vs. boreal winter (December-February) nesters. Individuals nesting in Papua Barat, Indonesia during July (2003, 2005, 2006, 2007) migrated to foraging areas within multiple temperate regions of the North Pacific Ocean and tropical waters of the South China Sea, remaining north of the equator at all times. In contrast, individuals tagged at the same Papua Barat beaches during January-February (2005, 2007) moved southward, similar to nesting leatherbacks tagged during these months in Papua New Guinea and the Solomon Islands (2001, 2003, 2006). Destinations for these boreal winter nesters included the temperate South Pacific between southeastern Australia and New Zealand's North Island, and tropical regions south of the equator, particularly the Banda Sea. The arrival of leatherbacks at northern temperate destinations coincided with periods of peak marine productivity. Off the U.S. West Coast, leatherbacks arrived during July-August to exploit the seasonal dense aggregations of sea nettles, *Chrysaora fuscescens*, an important prey species. We hypothesize that the timing of arrival at southern temperate destinations also coincides with peak prey availability in these locations.

## **OXYGEN CONSUMPTION AND SWIMMING EFFORT OF HATCHLING GREEN TURTLES**

**David T. Booth**

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Swimming effort and oxygen consumption of newly emerged green turtle hatchlings was measured simultaneously for the first 18 hours of swimming. Oxygen consumption was tightly correlated to swimming effort during the first 12 hours of swimming indicating that swimming is powered predominantly by aerobic metabolism. The patterns of swimming effort and oxygen consumption could be divided into three distinct phases: (1) The rapid fatigue phase from 0 - 2 hours when the mean swim thrust decreased from 45 mN to 30 mN and oxygen consumption decreased from 33 ml/h to 18 ml/h; (2) The slow fatigue phase from 2 - 12 hours when the mean swim thrust decreased from 30 mN to 22 mN and oxygen consumption decreased from 18 ml/h to 10 ml/h; and (3) the sustained effort phase from 12 - 18 hours when mean swim thrust averaged 22 mN and oxygen consumption averaged 10 ml/h. The decrease in swimming thrust was caused by a combination of decreases in front flipper stroke rate during a power stroking bout, a decrease in mean maximum thrust during a power stroking bout, and a decrease in the proportion of time spent power stroking.

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## **RECONSTRUCTION OF HISTORIC SEA TURTLE POPULATIONS AROUND MAURITIUS AND IDENTIFICATION OF APPROPRIATE CONSERVATION GOALS FOR A GHOST POPULATION**

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In prehistoric times, sea turtles were found in their thousands feeding in the waters and nesting on the beaches of Mauritius. Early explorers and settlers described visiting the uninhabited island from the 1600s and heavily exploiting stocks which provided a valuable source of meat and eggs. Sightings of these animals are now rare and only two nesting events have been officially recorded on the island in the past 30 years, the most recent being in 2007. In the absence of scientific data or publications on sea turtle populations, oral histories concerning traditional and local knowledge were analysed in conjunction with historical records from a 400 year period in order to reconstruct population dynamics and incorporate the concept of shifting baselines in future conservation initiatives. This reconstruction provides a vital means to assess the historic and contemporary threats to the relict or 'ghost' population and therefore identifies appropriate conservation measures considered within the context of past population levels. A suite of recent threats which have emerged since the mid 20th century, such as coastal development, boat traffic and pollution have also been analysed and considered within this broader historical context. This study illustrates how such reconstruction is essential when setting realistic and measured conservation goals for a species which has been heavily exploited for centuries before the establishment of quantifiable baseline data.

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## **‘SHARED SEAS’: MARINE TURTLES IN THE ARAFURA-TIMOR SEAS**

**Kiki Dethmers<sup>1</sup>, Ray Chatto<sup>1</sup>, Narciso A. de Carvalho<sup>2</sup>, and Karen Edyvane<sup>1</sup>**

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The Arafura-Timor Seas are a global hotspot for marine biodiversity, with strong, regional-level connectivity in oceanographic processes and biodiversity, particularly, in the movements of pelagic and migratory species. Six of seven marine turtle species are widely distributed throughout this region. However, this region faces major threats from climate change, unregulated and illegal fishing and impacts of marine debris, threatening the persistence of turtle populations. Conservation efforts in this region faces management challenges characteristic of many remote regions, including the lack of baseline information, limited marine policies and strategies, lack of marine conservation planning, limited capacity and resources, and low public awareness. Recently, the Timor Leste Government, in collaboration with AIMS and the Northern Territory Government commenced monthly aerial surveys to determine the distribution, density and behaviour of marine wildlife in the Timorese coastal seas. The primary aim is to identify potential marine megafauna ecotourism opportunities in Timor Leste. In addition to the aerial surveys, field ground-truthing of turtle nesting observations, market interviews and shell/turtle egg measurements are used to identify nesting season and densities of various marine turtle species. To date, there have been many sightings of large pods of dolphins & small whales. One whale shark and one sperm whale were observed during the survey in June 2008. Several large crocodiles were observed in beach areas. However, while turtles of various size classes were observed at the sea surface, the aerial surveys showed very little evidence of turtle nesting. The interviews and measurements of turtle eggs revealed that nesting on beaches east and west of Dili is sporadic and only by olive ridley (*Lepidochelys olivacea*) and hawksbill (*Eretmochelys imbricata*) turtles. Further evidence revealed that juvenile green turtles (*Chelonia mydas*) are caught in fishing nets off the coast from Dili. If the trend is consistent through time - human predation on eggs might be considered as a serious problem. Surveys are currently ongoing and the collected information is compared to observations along the North coast of Australia and the Aru Islands in Indonesia. Marine turtle conservation in the Arafura-Timor seas needs to address the complex issues associated with both, indigenous rights and interests and also, the trans-boundary issues in the region, such as illegal fishing, habitat degradation and food security. This paper discusses these issues in light of the persistence of marine turtle populations in the Arafura-Timor Seas.

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## **CAN CASUARINA AS SHELTERBELTS SPELL DOOM FOR THE LEPIDOCHELYS OLIVACEA NESTING ALONG SOUTHERN CHENNAI COAST IN INDIA?**

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The South Eastern coast of India hosts sporadic nesting sites for the endangered olive ridley sea turtle. This paper puts forth the impact of a *Casuarina* plantation as shelterbelt on the nesting beaches of olive ridley sea turtles along the East Coast of India. A study was undertaken by conducting two field surveys at a stretch of about 16 km each along the Kancheepuram coast, Tamil Nadu, India. The observations and recommendations are provided in this paper. *Casuarina equisetifolia*: A tree also known as the Australian pine has been planted along the Kancheepuram, Tamil Nadu Coast as a ‘Shelterbelt’ by the Forest Department. All saplings have been planted one meter or so from the high tide leaving no open beach, of which the first line of saplings have already been washed away and subsequent ones are dying due to continuous load of salt spray. Observations of the *Casuarina* plantations along the Kancheepuram Coast were listed. The impact of the above on native species (flora and fauna) and sea turtles was assessed and elucidated. Logistics of irony of shelterbelts as ‘bio-shield’ in the name of tsunami protectors, wave breakers, cyclone barriers executed by the forest departments in different states in India as Emergency Tsunami Restoration Program (ETRP) was enunciated by showing the utility of the same as cash crop by forest departments. Recent human intelligence of certain state premiers has been elevated by their order to do extensive plantation along the coast as mitigation for sea level rise by taking a toll of complete destruction of natural coastal habitat. Such human efforts for destruction of coastal biodiversity were

explained. These beaches were open flat beaches with gradual slopes usually preferred by turtles. The resident fishermen also observed that they used to see at least 15 or more turtle nests in the past (before the *Casuarina* plantation) in each of the villages (3km stretch). The decline in nesting if at all true, then can be attributed to the change of beach profile and *Casuarina* plantation alike. From the observations, it was noted that the beach profile had been altered, where small numbers of turtles were nesting. Any group of nesting turtles may constitute a genetically unique and vulnerable unit; therefore losing even small populations may mean the permanent loss of diversity.

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## **USE OF MICROSATELLITE MARKERS FOR EVALUATING THE RELATEDNESS AMONG GREEN TURTLE NESTS FOUND ON THE MAIN HAWAIIAN ISLANDS**

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Almost all green turtle nesting in the Hawaiian Islands occurs at French Frigate Shoals (FFS), a remote reef with several sand islets located at the midpoint of the 2400 km linear archipelago. However, there have been sporadic nestings observed on the beaches of the main inhabited islands, including Kauai, Oahu, Maui, and Molokai. Given the low numbers of nestings monitoring is confined to observation of nests. In the absence of tagging, it is unclear how many females are nesting on the main Hawaiian Islands. We developed and tested a genetic approach to inferring the number of individual nesters from genotypes determined from dead embryos and hatchlings sampled from a total of 23 nests laid on the main Hawaiian Islands. Samples were salvaged from non-viable embryos following emergence of the nests, and were from one nest laid in 2004, four nests laid in 2006, and 18 nests laid in 2007. We also have samples from 13 nests laid in 2007 on the northwest Hawaiian Islands. We used mitochondrial DNA (mtDNA) sequencing combined with nuclear DNA analysis with 17 microsatellite markers to evaluate the relatedness of these nests to each other as well as to the nesting females of French Frigate Shoals. Our results show that these genetic tools can be applied to provide insights for population assessments where access to nesting females is difficult.

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## **SEARCHING FOR THE BEST HISTORICAL RECORD IN THE CARAPACE OF GREEN TURTLES**

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The use of stable isotopes (SI) to infer different aspects of the biology of sea turtles, such as changes of habitat and diet throughout their life history, is increasing at a fast pace. Using the appropriate sample allows the researcher to interpret the historical record of the organisms under study more accurately. SI analysis of scute samples in sea turtles provides a record of changes in diet and habitat across time due to the growth layers in the tissue. Scutes grow in layers throughout the life of a sea turtle so that the oldest retained layer is closest to the surface. The ideal sample for stable isotope analysis is that in which the greatest number of layers over the longest period of time are included. However, locating the best spot for sampling is not straightforward. The number of layers in each scute can vary according to the position on the carapace (due to sloughing and abrasion), and can also vary within the same scute (more layers are retained in the posterior end of the scute than in the anterior portion). The purpose of this project was to determine the best sampling location in the carapace and improve the methodology for collecting sea turtle scute samples for SI analysis. We analyzed the thickness of all lateral and central scutes from four juvenile green turtles that had stranded on the west coast of Florida (between 23.2 and 33.3 cm straight carapace length). The thickness of each scute was measured to the nearest 0.003 mm along 3 to 5 transects (depending on the scute size) and the thickest point was determined. Despite differences in carapace length of the turtles, the same pattern in thickness was found in all turtles: the second lateral

scutes were the thickest. Within the scute, the sample from the posterior medial area was the thickest. However, because this area yields the thickest sample, collection of samples from this location is challenging. The use of biopsy punches often requires extensive handling time of the turtle and the use of additional biopsy punches to obtain the sample. To solve this problem we developed a technique that facilitates the collection of samples and reduces the handling time of the turtle. *Acknowledgements:* Support from the following organizations made my assistance to the symposium possible through a travel grant award: Australian Government DEWHA, Queensland Environmental Protection Agency, Disney Animal Kingdom, Western Pacific Regional Fisheries Management Council, U.S. National Marine Fisheries Service, U.S. Fish and Wildlife Service (Marine Turtle Conservation Fund), and the Marisla Foundation.

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## **SOCIAL AND ECONOMIC FACTORS DRIVING ILLEGAL SEA TURTLE FISHERY AND TRADE IN BCS, MEXICO**

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Although a total ban on the sea turtle fishery was declared in Mexico in 1990, sea turtle consumption and trade is still common in many coastal areas and particularly in Baja California Sur (BCS). Recent studies demonstrated that directed catch for consumption and trade is one of the main mortality causes for sea turtles in BCS. However, very little information on the number of sea turtles caught and on the benefits for the fishermen (albeit illegal) is available. This study aimed to: 1) estimate the number of sea turtles killed per year for commercial purposes; 2) determine the costs and benefits of the illegal sea turtle fishery in BCS; and 3) identify social and economic factors driving fishermen to this activity. We conducted structured interviews with illegal poachers at 5 coastal communities where there is a developed sea turtle market. Qualitative information was used to describe sea turtle regional traffic in BCS. Quantitative information was used in a model that helped establish why fishers decided to engage in an illegal activity. Based on interviews with 8 illegal poachers (approx 10% of total number of known poachers), we estimated that every year between 10,259 and 33,398 sea turtles are killed and enter a regional black market. This represents a gross revenue of more than \$540,000 USD for the fishermen and a revenue of \$947,000-1,080,000 USD for the middlemen. It is inferred from the model that the illegal sea turtle fishery is a profitable activity with a relatively low risk of being apprehended. Furthermore, while the penalty is a good deterrent, the lack of law enforcement and scarce compliance are among the key drivers of this illegal fishery, along with the economic incentive. In addition, sea turtle consumption is still socially accepted as part of BCS cultural background. As the number of sea turtles killed per year could seriously affect the recovery of the population, an immediate solution is needed. Specifically, it is essential to improve detection methods and law enforcement. However, conservation and education programs are also needed to reduce peoples' acceptance of sea turtle poachers.

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## **DISPERSAL PATTERNS AND SWIMMING BEHAVIOUR OF HATCHLING FLATBACK TURTLES (*NATATOR DEPRESSUS*)**

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The flatback turtle (*Natator depressus*) is the only species of sea turtle endemic to the Australian continental shelf and therefore has one of the most restricted geographic ranges of all sea turtles. However, the IUCN Red List classifies it as "Data Deficient," as it is one of the most poorly understood turtle species. Threats facing adult flatback turtles are similar to those for other species, including fishing operations, marine debris and coastal development. However, flatback turtle hatchlings inhabit a unique environment compared to the other species and face different threats to their survival. The 'lost years' for the other 6 species of sea turtles are spent in the open ocean. Flatback hatchlings do not

enter a pelagic phase but remain in coastal waters, making them vulnerable to human activities contributing to decline in water quality and loss of suitable habitat. This also allows an excellent opportunity for visual tracking and radio telemetry to monitor their dispersal and swimming behaviour. During this study, researchers followed flatback turtle hatchlings in kayaks, monitoring their swimming speed and direction to determine their dispersal patterns and preferred habitats in these in-shore waters. Twenty-five hatchlings were followed from Peak Island into Keppel Bay for periods of 10 mins to 3 hrs and distances between 300m and 1170m depending on the weather. Hatchling position (latitude and longitude) was recorded every 10 mins. Results indicate local currents play an important role in flatback hatchling dispersal from the natal beach.

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## **EYES IN THE SKY: DEFINING A LOGGERHEAD FORAGING HOTSPOT IN THE EASTERN PACIFIC THROUGH AERIAL SURVEYS**

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For nearly two decades, scientists have known that loggerhead turtles originating from Japanese nesting beaches cross the Pacific Ocean to access the productive waters off the Baja California Peninsula, Mexico. Less understood are how many turtles occur in this area and how persistent is the hotspot from year to year? More importantly, it remains unclear how important this foraging assemblage is for the overall North Pacific loggerhead stock. At a time when loggerheads continue to face substantial threats in the world's oceans, there is a critical need for more information from foraging populations to better understand conservation status and demographic structure of loggerhead stocks worldwide. Our goal is to describe this unique aerial survey effort and provide answers to these burning questions. We will also highlight the value of aerial data for augmenting traditional in-water monitoring and satellite telemetry research programs. Loggerhead surveys were conducted along the Pacific Coast of the Baja Peninsula from 2005 to 2007. We followed a line-transect protocol that encompassed nearly 7,000 km of track-line each year, with offshore extents to 170 km. Nearly 1,000 loggerheads were sighted along with a variety of other turtle and marine vertebrate species. Our sightings were strongly linked with mesoscale oceanographic features, and our estimates derived from these data indicate that tens of thousands of loggerheads are present each year in Baja's offshore waters. As one of the major U.S.-Mexico cooperative research efforts, we believe that the loggerhead aerial survey program underscores the value of binational partnerships for addressing sea turtle conservation challenges.

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## **THE INFLUENCE OF THE WORLD BANK ALONG INDIA'S COASTAL HABITATS**

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An investigation into the World Bank's influence along the coastline in India through its funded projects reveals that it is now on the threshold of changing the face of sea turtle habitats in the name of post-tsunami reconstruction and sustainable coastal management. The World Bank is currently involved in two projects along coastal areas in India. The Emergency Tsunami Reconstruction Project (ETRP) was initiated after the 2004 tsunami and its objectives were to provide immediate and intermediate assistance to the Government of India and state governments along the coast for the revival of livelihoods in tsunami-affected states. The Integrated Coastal Zone Management Project (ICZMP), also funded by the World Bank addresses issues of coastal management. The rationale for the Bank's involvement in the ICZMP is based on the recommendations of a review of the current coastal regulation legislation. Factors common to

both these projects stress on the inclusion of physical and/or structural measures, of which the planting of “bioshields” on sandy beaches, among others, has become contentious. Critics of a legislation proposed by the Indian Government, which embraces these concepts, advise against such measures, emphasizing detrimental ecological and social impacts. But in this context there has not been much deliberation on how the Bank has played a part in endorsing what the Government proposes to be appropriate management of the coast. Groups working on turtle conservation along the east coast of India have questioned such measures taken by the Bank, and are currently trying to involve both the local governments and the Bank in discussions to determine the ecological consequences that such measures will have on coastal habitats and the bearing it will have on conservation efforts that have been in place so far. But the process by which the initiation of such measures takes place is perhaps equally, if not more important to determine the degree to which adherence to scientific principles, accountability, transparency and participation are given priority by the Bank. While the Bank’s policy documents seem to indicate that these processes are imperative in such projects financed by it, studies carried out by various groups and our own investigations show that on many accounts, they have been sidelined, if not completely ignored. Many of the Bank’s project interventions are located along important turtle nesting sites. In addition to researching the ecological impacts on the shoreline ecosystem, it is crucial to understand how financial institutions like the World Bank influence these regions through the governments that they finance. Our work involves a thorough analysis of reports and documents of both the Government and the World Bank to scrutinize the rationale for inclusion of such measures in their promotion of coastal management. And while most efforts to confront the Bank so far have been in relation to measures suggested in the ETRP, the interactions of the aims of the ETRP with that of the ICZMP will compel the Bank to justify whether its idea of ‘sustainable coastal management’ provide room for appropriate coastal protection and conservation of beach habitats.

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## **DEVELOPMENT OF REGIONAL MANAGEMENT UNITS FOR SEA TURTLES: APPLICATIONS FOR THREATS EVALUATION, GAP ANALYSES, DIVERSITY HOTSPOTS ASSESSMENT, AND CONSERVATION PRIORITY SETTING**

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Linking impacts of various hazards to biological populations of widely distributed marine megafauna (e.g. sea turtles) requires description of overlaps of spatial extents of hazards as well as geographic distributions of the population unit of interest. However, population segments can be described using distinct tools or indicators, such as information from genetics, behavior, or morphology. In turn, because individual hazards can operate on varying spatial scales, their impacts can affect different segments of a population of the same species. To address these issues for sea turtles globally, we first collated all available studies on population genetics and satellite telemetry, as well as other relevant natural history and biogeography studies, to generate polygons that contained nesting stocks, reproductive populations, and distributions of population segments of all sea turtle species. We also compiled information on population sizes and trends at each spatial/biological scale. We then spatially integrated this information from fine- to coarse-spatial scales such that individual nesting beaches are grouped as nesting stocks (according to mtDNA studies), which are then nested within breeding populations (according to nDNA studies), which are then nested within the known geographic ranges of the units (according to satellite telemetry and tag return data). The products are nested envelope models, or ‘Regional Management Units’ (RMUs), for each world region for each sea turtle species, which provide a framework for evaluating threats, identifying data gaps, and assessing high diversity areas for multiple species and genetic stocks. Although the technique should be considered qualitative because precise geospatial metadata are generally unavailable for generating these RMUs, our approach is methodologically robust because it reflects only summarized data available in the published literature. The advantage of this approach is the ability to connect impacts of particular hazards to biologically relevant units and their associated demographic characteristics. Ultimately, this framework will be fundamental for setting conservation priorities at different levels of spatial and biological organization for sea turtles globally.

## **TURTLE USE/ SUSTAINABLE USE**

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### **ASSESSING THE ECONOMIC VALUE OF SEA TURTLE HUNTING TO INFORM SEA RESOURCE MANAGEMENT POLICY IN THE TORRES STRAIT, AUSTRALIA\***

**Aurelie Delisle**

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The waters of Torres Strait in Northern Australia are home to six species of marine turtle, all of which are on the list of threatened species under Australia's Environment Protection and Biodiversity Conservation Act 1999. Australians regard sea turtles as iconic species for the important place they have in Australia's rich and unique marine biodiversity. In the mean time, Indigenous Australians highly value marine turtles for their economic, social, cultural and spiritual importance and Torres Strait Islanders are allowed under Australian law to hunt turtles for the purpose of subsistence. Management arrangements that seek to respect all these values will need to ensure the sustainable use of marine turtles in the Torres Strait waters and cannot be developed without the strong involvement of Torres Strait Islanders. Optimally, this can be achieved if policy makers are given information on the full costs and benefits (market and non-market) that influence sea turtle hunting in the Torres Strait. However, it is difficult to estimate non-market values. A modest step forward is to work closely with Torres Strait communities to estimate the financial value of sea turtle hunting. In 2006, the strategic assessment of the sea turtle fishery in the Torres Strait that was undertaken under the Environment Protection and Biodiversity Conservation Act review process evaluated the economic value of the turtle catch in the Torres Strait Protected Zone at \$600,000 to \$800,000 per year. Based on these estimates, this paper highlights that sea turtle hunting is equivalent to 0.95% - 1.27% of the gross weekly income of Torres Strait Islanders living in the Torres Strait Protected Zone. In comparison, Queenslanders spend on average 1.30% of their gross weekly income on meat products. This indicates that sea turtle catch help Torres Strait Islanders save between 73% and 98% on their weekly meat budget. With the help of Torres Strait Islanders, other financial costs involved in sea turtle hunting will also be evaluated. This preliminary assessment of the financial value of sea turtle hunting in Torres Strait will then be used to inform policy makers about the use of different management arrangements such as meat subsidies.

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### **CULTURAL ANTHROPOLOGY OF TASTE IN PEARL LAGOON: SOCIAL AND ECONOMIC FACTORS DRIVING GREEN TURTLE CONSUMPTION IN CARIBBEAN NICARAGUA**

**Katy Garland<sup>1</sup>, Ray Carthy<sup>1</sup>, Charles Wood<sup>1</sup>, Lance Gravlee<sup>1</sup>, Cathi Campbell<sup>2</sup>, Susan Jacobson<sup>1</sup>, and Perran Ross<sup>1</sup>**

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For my doctoral dissertation I am researching the cultural factors driving the consumption of green turtles (*Chelonia mydas*) in the community of Pearl Lagoon, Nicaragua. In this presentation, the preliminary results from five months of research (conducted from June to November 2008) are analyzed and explained. The sea turtle fishery on Nicaragua's Caribbean coast is a prime example of the influence of natural resource use, dietary customs and market influence on environmental conditions. As early as the 19th century, Bernard Nietschmann reported that the Miskitu Indians made use of the largest sea turtle feeding grounds in the Western hemisphere, deriving 82% of their meat harvest from aquatic resources. Historically, 65% of Miskitu men devoted their meat-gathering time only to the harvesting of turtles and the protein obtained by these fishermen remained in their local communities. However, due to an increase in market demand for turtle meat (throughout Nicaragua) and shell (mostly in Asia), the Miskitu economy quickly became more dependent on cash in the mid 1900s. To meet rising market needs, the traditional Miskitu turtle men and other

Nicaraguan fishermen altered their subsistence fishing strategy to one of mass exploitation. While there is a growing interest among coastal communities to pursue more sustainable uses of natural resources, such as sea turtles, local participation in conservation efforts is minimal. This lack of involvement likely results from a historical preference for turtle meat and the lack of cheap, alternative sources of protein. Currently, year-round unlimited legal harvests of *Chelonia mydas* take place along the Caribbean coast. The only times that people don't harvest turtles are when the weather is bad or when they are on holiday. Community-based conservation programs in Caribbean Nicaragua aim to decrease (or eradicate) the high level of marine turtle exploitation in coastal indigenous communities, through education and training in alternative options. This research will provide valuable information for many similar community-based conservation initiatives. Policy-makers and local enforcement agencies will be able to make use of the statistically robust data. The most significant international threats to sea turtle populations are the direct result of human actions. However, by carefully examining the conditions behind consumptive use of sea turtles and addressing the cultural practices and social pressures associated with this exploitation, we have a chance to successfully change this destructive course. There are many challenges in the conservation of sea turtles, but the clear need for protection of these species and their habitats is immediate and imperative to conservation efforts. The loss of sea turtles represents a threat to far more than one species of commercial value. The historic, spiritual, and cultural connections to these animals can be used to harvest the political will needed to recover sea turtle populations. This study assists in determining the conditions behind cultural and historic connections of sea turtle consumptive use and assists U.S. and international conservation agencies in the creation of successful initiatives to protect sea turtles and recover their populations.

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## **A TOOLBOX OF TOOLS FOR MANAGING THE TORRES STRAIT GREEN TURTLE FISHERY\***

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The Torres Strait green turtle fishery is essentially unregulated. Management of this fishery is complicated because of the complex nature of the 1) biology and ecology of the species; 2) hunting patterns and socio-cultural considerations of the hunting communities; and 3) jurisdictional arrangements. The acceptability of management tools to Islanders is likely to depend on their knowledge and experience of those tools. Most of the commercial fisheries in Torres Strait are managed using total allowable catches. The green turtle and dugong fisheries are subject to input controls which limit who may participate (traditional inhabitants only), the vessels that can be used (6m or less in length) and, in the case of dugongs, a spatial closure and gear restrictions. However, these management tools are designed more towards maintaining the fishery as a traditional non-commercial fishery rather than controlling the level of take. Torres Strait communities are developing management plans for these fisheries. We provided an analysis of several different management tools, including quota/permit systems, spatial closures, temporal closures, size and sex limits, gear restrictions and cultural restrictions. For each management tool, we identified the characteristics that would be needed to make it successful with respect to biological and ecological data, planning, monitoring/evaluation and enforcement. We then identified the pros and cons of each management tool in light of our understanding of, or ability to achieve, the characteristics needed to make it successful. Hunting information and demographic data were obtained from Kaiwalagal hunters participating in a community-based catch-monitoring programme. Torres Strait communities have not had the benefit of a detailed analysis of the pros and cons of the different management tools available to manage their green turtle fishery. Their draft management plans include many of the tools considered here, but notably they are against taking male or juvenile turtles instead of adult females. Each management tool has distinct pros and cons and the amount of information, money, social support and data required to make each tool work differs. These differences mean that no one tool will stand out clearly as the best and a variety of tools may be needed. The main conclusion is that each tool requires strong community support at the level of both individual communities and island nations. In addition, communities need overarching support at the Torres Strait level to provide guidance and assistance for planning and implementation. Such capacity building needs to include building Islander understanding of scientific knowledge as well as logistical assistance. This analysis will provide Islanders with a type of "score sheet" from which they can sum up their own pros and cons from a community or nation perspective. This score sheet could also be used by other agencies (e.g. Queensland Boating and Fisheries Patrol) to easily determine where their support would best be placed. This analysis would also guide the Torres Strait Regional Authority and the Australian Fisheries Management Authority in supporting turtle and dugong management in Torres Strait. Furthermore, it could be used to direct research to fill in information and/or management gaps.

## **DO TOURIST ACTIVITIES AFFECT GREEN TURTLE (*CHELONIA MYDAS*) NESTING BEHAVIOUR AND HATCHING SUCCESS AT TORTUGUERO, COSTA RICA?**

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Tortuguero National Park in Costa Rica has become an extremely popular tourist destination. Since the early 1980's tourism has increased dramatically from less than 1,000 people per year to more than 116,000 visitors in 2007. Of the tourists who visit Tortuguero, around 40,000 people a year participate in organized turtle tours during the green turtle nesting season. National Park staff impose strict controls to minimize negative impacts to turtles as a result of tourist activities; all tour groups require a registered guide, visitation is limited to a small section of beach and time limits are imposed. Since 2004, the Caribbean Conservation Corporation, together with Tortuguero National Park and the local community, has implemented a new turtle visitation system known as the Turtle Spotter Program to reduce the disturbance to turtles by human presence on the beach. Since its inception, there has been a documented increase in the proportion of nests to false crawls, as a result of fewer emerging turtles being disturbed by tour groups. The Turtle Spotter Program limits the time groups are on the beach, it also minimises the distance that tourists are walking and controls the number of people around the turtle. However, there are still concerns that the presence of tourists may adversely affect female nesting behaviour and that the physical action of people walking on a nest will lead to reduced hatching success. This paper will discuss the results of investigations undertaken at Tortuguero in 2008 to address these important concerns. Firstly it will compare the behaviour of 'experimental' females (observed by tour groups) to that of 'control' individuals observed only by researchers. Each phase of the nesting process was timed, from oviposition to the turtle returning to the sea, to determine if any significant differences in behaviour exist between the two study groups, and to ascertain if such behavioural changes can be correlated to the number of tourists present during nesting. Secondly, the results of a trampling study will be examined. The hatching success of pairs of 'experimental' and 'control' nests will be compared, to assess the impact of physical trampling (such as that resulting from tourists walking over a nest). 'Experimental' nests were subject to either 'high' or 'low' levels of trampling throughout the incubation period; 'high' was the equivalent of 10 tour groups passing over the nest, 'low' the equivalent of two tour groups. It is hoped that the findings from these studies will provide scientific justification for the continued implementation of the Turtle Spotter Program at Tortuguero, and enable Tortuguero National Park to establish limits relating to the maximum number of tourists present around a single turtle at any given time. They will also provide valuable information for other nesting beaches where tourism is permitted, allowing better management of tourist activities to prevent potentially damaging uncontrolled tourist access, and so improve turtle conservation efforts.

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## **PROGRESS TOWARDS A SUSTAINABLE GREEN TURTLE FISHERY ON THE CARIBBEAN COAST OF NICARAGUA\***

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Marine turtle mortality on the Caribbean coast of Nicaragua is high. Annual mortality levels range from hundreds of hawksbills and loggerheads to thousands of green turtles. Although laws exist to fully or partially protect marine turtles in Nicaragua, environmental laws are rarely respected and inadequately enforced. Since 1997, we have been conducting conservation activities on the Caribbean coast of Nicaragua aimed at local resource users; and local, regional, and

national authorities. In collaboration with local stakeholders through community and regional level meetings, we have developed a management strategy for marine turtle conservation. From the strategy, management action plans for each autonomous region on the Caribbean coast of Nicaragua have been developed and recently approved by the autonomous governments. In addition to other regulations, each plan calls for reduced levels of take of green turtles and regulates markets and commercialization between regions and among communities. For the first time, regional and local authorities in Nicaragua are making difficult decisions about natural resource use and are taking important steps towards making the Nicaragua green turtle fishery sustainable.

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## **MARINE TURTLE CONSUMPTION AND TURTLE SHELL TRADING AS MAJOR THREATS TO FIJI'S TURTLE POPULATIONS: A CASE STUDY IN THE MAMANUCA ARCHIPELAGO AND MUNICIPAL MARKETS AROUND VITILEVU, FIJI\***

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In Fiji, a long history of marine turtle exploitation for subsistence, traditional and commercial use has been intact since precontact era. The assessment of marine turtle harvests was piloted in the Mamanuca group with market survey in all the municipal markets. The household and market survey were conducted to justify the need to extend the Turtle Moratorium expiring in December 2008. The moratorium lays a total ban to the harvesting and trading of turtles and its derivatives with exemption to traditional occasions. The household survey was conducted through questionnaires and group discussions in the four villages of Solevu, Yaro, Yanuya and Tavua in the Mamanuca group in 2007 whereas the market survey was conducted in all municipal markets around Viti Levu Island in April, 2006 and from December to February 2007 (Fig 1 & 2). The market survey included measurements of the turtle's curved carapace length, number of carapaces, species, number of derivatives (such as bangles, spoons, necklaces, earrings) and costs of the carapaces and shells products. The household survey showed that a total of 241 turtles were consumed in the four villages for both traditional occasions and for household subsistence consumption. More turtles were found to be consumed in traditional occasion (153 turtles) as compared to subsistence consumption (88 turtles). The identified traditional occasions include death, weddings, birthdays and other occasions (church or school functions). A total of 104 turtles were consumed in death occasions, seven in weddings and 42 in church and school functions. There were 102 outlets in Fiji that were surveyed in the Market survey. A total of 57 carapaces were found sold in the markets, where 29 carapaces were green, *Chelonia mydas* and 28 were hawksbill, *Eretmochelys imbricata*. More carapaces were found in April as compared to December -February. This could be due to December being within the breeding season (Amended Fisheries Act –CAP 158, 1998). The results also indicated that the average harvesting sizes of hawksbill turtles ranges from 40cm to 46 cm curved carapace length (CCL max) and green turtle of an average 49cm to 51 cm curved carapace length ( $P < 0.005$ ). The values indicated that turtles caught tended to be juveniles and sub adults of green and hawksbills which are the most common species in Fiji ( $P < 0.005$ ). This study provides an insight of anthropogenic threats to Fiji's turtle population. The results also justify that the current Turtle Moratorium (2004-2008) (Fisheries Act CAP 158) should be extended for the recovery of Fiji's turtle population. In addition, more effort needs to be focused on raising awareness in communities on turtle conservation.

## **TORRES STRAIT MARINE TURTLE AND DUGONG PROJECT – COMMUNITY-BASED MANAGEMENT AND PLANNING\***

**Frank Loban and Lachlan Sutherland**

Torres Strait Regional Authority, Thursday Island

Beginning in 2006, 8 indigenous communities located in the Torres Strait, Australia have been involved in the Dugong and Turtle Project. A primary focus of the project has been the development of community-based management plans. These communities included Badu, Mabuiag, St. Pauls community – Moa, Boigu, Iama (Yam), Erub (Darnley Island), Mer (Murray Island) and Ngurupai (Horn Island). The project is a first of its kind and has involved a collaborative approach from Torres Strait Islanders (TSI) and relevant stakeholders including the Australian Government and research Institutions for it to be a success. Turtle based research and monitoring has been a key component of the project in exposing TSI communities to contemporary turtle conservation issues and research activities. Hands on traditional owner involvement have been facilitated between participating communities and James Cook University and while providing technical skills has increased community awareness of turtle management and conservation issues. These experiences have been incorporated into the planning process. The plans are community developed and integrate a range of cultural hunting protocols and traditional knowledge with fisheries management strategies. Some proposed management arrangements include seasonal closures, gear restrictions, closed areas, effort reduction, limits on take, compulsory sharing and permit systems. The plans also propose ways in which community research and development priorities, education and training needs can be addressed; as well as enforcement and compliance processes. Project officers have developed first year operational plans or work plans to guide plan implementation and scope out the initial activities of a proposed Ranger Program. Torres Strait Islander project officers will present on their individual communities involvement in the project, how it has influenced thinking on their islands, between islands, some of the obstacles and challenges and changes in attitude towards turtle and dugong management. The Torres Strait Regional Authority (TSRA) is a statutory authority which is coordinating the project in the Torres Strait. The TSRA project liaison officer will also present how the planning process has supported and reinforced indigenous hunting rights as well as community based management of these species through collaborative partnerships with other stakeholders.

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## **TOURISTS AND TURTLES: SEARCHING FOR A BALANCE IN TORTUGUERO, COSTA RICA\***

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Tortuguero, Costa Rica is a ‘successful’ turtle tourism destination that now receives over 116,751 tourists a year (ACTo 2007). In 2004, the Caribbean Conservation Corporation advocated for and helped to implement a substantial change in the turtle tour system. The organization suggested a link between turtle tours on the beach (heavy foot traffic) and an increase in the number of false crawls in that area (Troëng 2004). Tourists and their guides once walked their allotted beach section for up to two hours, searching for a nesting turtle to watch. In 2004, a pilot study of a new Turtle Spotter Program was conducted on half of the beach; with the tourists and their guides allocated to designated waiting areas behind the beach, awaiting the assistance of ‘Turtle spotters’. The ‘spotters’ on the beach would radio location information about turtles ready to be viewed to the waiting tour groups. Using a trail behind the beach, tourists would then access the beach, close to the turtle. In 2005, this system was expanded to include the entire beach section used for turtle tours. The change was initiated with the turtles’ wellbeing in mind. According to the literature on ecotourism and wildlife viewing, however, such a system might not cater well to the needs of some turtle viewing tourists since the tours are now a more passive undertaking (more waiting, less walking). In the summer of 2008, Meletis surveyed 166 tourists who had participated in turtle tours, to collect data on perceptions of the new system. In this paper, we present an analysis of the survey data, and contextualize it within the relevant literatures; we focus on levels of tourist satisfaction, their assumptions regarding the tours, their concerns regarding tourism’s potential impacts on sea turtles, and related potential changes to the Turtle Spotter Program.

## **MALAMA NA HONU: PERCEPTIONS OF VOLUNTEERS AT LANIAKEA BEACH, OAHU, HAWAII**

**Robert H. Schmidt**

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Since 1999, Hawaiian green sea turtles (*Chelonia mydas*) have been basking on Laniakea Beach on Oahu's North Shore. Through the efforts of NOAA biologist George Balazs and others, a visitor management program ("Show Turtles Aloha") was established, with volunteer Honu Guardians assisting visitors in proper etiquette around basking honu (Hawaiian for green sea turtle). In 2007, the overall management of the Honu Guardians was organized under the Malama na Honu Foundation. Honu spectator management at Laniakea Beach differs from those visiting sea turtle nesting sites and people swimming or diving with sea turtles. The undeveloped beach is shared with fishers, surfers, swimmers, beachcombers, dog-walkers, and local and international tourists. Dozens of people surround basking honu, sometimes impeding their emergence from the water. Occasionally, inappropriate behaviors, some serious, occur around these honu, and the Guardians staff the beach throughout the day to prevent any negative interactions. There are also many opportunities to educate visitors about sea turtles in general, these particular honu, and sea turtle and ocean conservation issues and efforts. In this presentation, we review the "Show Turtles Aloha" program through the words, the eyes, and the reflections of the 50 plus Honu Guardians. Unlike many sea turtle ecotourism programs, there is no financial reward for the volunteers involved. Yet many volunteers have donated hundreds of hours to patrol the beach. Their experiences and observations, summarized here, may prove helpful in establishing other sea turtle conservation programs.

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## **COMBINING INDIGENOUS AND SCIENTIFIC KNOWLEDGE TO MANAGE MIGRATORY MARINE SPECIES ACROSS SCALES: CHALLENGES AND OPPORTUNITIES\***

**Kristen C. Weiss**

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Managing marine turtles invokes complex scale issues because their migratory routes typically cross jurisdictional boundaries. In Australia, the Native Title right which allows Traditional Owners to harvest sea turtles creates an additional scale challenge. A recent High Court ruling (the 'Blue Mud Bay decision') awarded traditional owners in the Northern Territory exclusive rights to intertidal waters on aboriginal land setting a new precedent for indigenous control over the management of sea country resources. These decisions provide an imperative, and an ideal opportunity, for increased indigenous involvement in marine management. Indigenous stakeholders bring a body of knowledge regarding marine wildlife that their communities have relied upon for countless generations to maintain their resource bases. Since 2005, the Commonwealth's 'National Partnership Approach' has mandated the incorporation of this Traditional Ecological Knowledge (TEK) into marine turtle management. Yet despite these legal advances, the consideration of how, and at what scales, indigenous knowledge and Western scientific knowledge (WSK) can be integrated into management and sustainable use strategies for sea turtles has largely been overlooked. I analysed much of the Australian literature pertaining to green turtle and dugong management from various indigenous and non-indigenous sources with the objective of understanding how current migratory marine species management in Australia has been informed by TEK and WSK. Using Nvivo, a qualitative research software tool, I explored how each document engaged with indigenous and western knowledge, focusing on the scales at which the two types of knowledge were gathered, understood, and applied to species management. I then compared these documents with the transcripts of my contemporary interviews with turtle and dugong Project Officers and administrative personnel of an indigenous government agency, the Torres Strait Regional Authority (TSRA), and with personnel from Giringun Aboriginal Corporation. Much of the non-indigenous literature acknowledges the detailed, holistic nature of Australian indigenous ecological knowledge. However, TEK tended to be narrowly categorized as place-based knowledge that was useful at the local level only. Conversely, the indigenous literature conveyed both the ecological and socio-cultural significance of TEK at multiple spatial and temporal scales, and openly discussed both the fragmented nature of WSK,

and the need for combining western and indigenous knowledge. However, indigenous authors did not often broach the challenge of managing wide-ranging migratory species such as sea turtles. TSRA and Giringun personnel, however, had a firm grasp on the multi-scale nature of marine turtle management and an explicit commitment to using both knowledge systems. This concurs with findings from North America that indigenous communities prefer to make resource management decisions using a combination of indigenous and scientific knowledge. These perspectives suggest that the scale challenges presently afflicting migratory marine species conservation in Australia largely result from inadequate communication and knowledge sharing between indigenous and non-indigenous stakeholders. Recognizing this deficiency will be a significant step forward for managers at the local level. Influencing stakeholders and policy at a broader level to reflect this understanding is a continuing challenge.

**Author Index**

- Abass, M.....165
- Abernathy, Kyler J.....131
- Abreu-Grobois, F. Alberto  
.....79, 82, 83
- Acevedo-Ruiz, E.....33
- Adegbile, O.....165
- Admire, Philip.....103
- Adyas, Ahmad H.....54
- Affronte, Marco .....117
- Aguirre, A. Alonso.....152
- Ajulo, A. ....165
- Akins, Leah .....121
- Al Dhafri, Khamis .....54
- Al-Alawi, W.....86
- Al-Amri, I.S.....87, 89, 95
- Al-Bahry, Saif N. 86, 87, 89,  
95
- Albavera, Ernesto.....34
- Alcantar-Armenta, J. ....147
- Alderson, Jesse E. ....38
- Alessi, Sarah C. ....95
- Alfaro-Shigueto, Joanna 65,  
72
- Al-Gharfri, Sabha.....89
- Al-Harthy, Asila.....86, 89
- AlKindi, Abdulaziz Y.A. 54,  
86, 87, 89, 95
- Allison, David.....46
- Almeida, Antônio P. ....112,  
123
- Al-Omairi, R. ....87
- Al-Rawahy, Salim H. 54, 86,  
87, 95
- Alvarez, Rocio E. ....87
- Alvear, Carlos A. ....87
- Al-Zadjali, M.A.....86
- Ambar, Stephen .....80, 176
- Ambio, Levi.....168
- Ambrose, E. E. ....165
- Amire, V. ....165
- Amorocho, Diego F.....65
- Andersen, Claire .....52
- Anderson, Paul.....132
- Andraka, Sandra .....46
- Andryszak, Bryan.....103
- Aniebona, F. ....165
- Antonio-P., Marco .....23
- Arenas, Alejandro.....83
- Arendt, Michael D. ....38, 97
- Arrecis, M.....147
- Austin, Timothy ..... 67
- Avens, Larisa..... 97
- Bachan, Allan .....133
- Bagley, Dean A..... 84
- Bailey, Helen.....130
- Baker, Michelle ..... 57
- Balazs, George H.....75, 84,  
171
- Ballorain, Katia.....66, 70
- Bangkaru, Mahmud .....144
- Barata, Paulo C.R.....123
- Barco, Susan..... 53
- Barra, Nathan ..... 17
- Barragan Rocha, Ana  
Rebeca.....132, 151
- Barrios, A. ....147
- Barrios-Garrido, Héctor A.  
.....39, 49, 101, 113
- Barros, Juliana A..... 67
- Barsante, Armando ..... 19
- Bass, Deborah.....132
- Bass, Oron L..... 64
- Bayhnam, Tim.....27, 137
- Bedford, Susie ..... 11
- Beggs, Jen .....35, 113

|  |   |  |
|--|---|--|
| <b>Bell, Catherine</b> .....67                             | <b>Bourjea, Jérôme</b> ..58, 66, 70,<br>114, 115, 133, 143, 153 | <b>Cañadas, Ana</b> ..... 74                     |
| <b>Bell, Ian P.</b> .....1, 80, 114                        | <b>Bowen, Brian W.</b> .....79                                  | <b>Canbolat, Ali F.</b> .....118                 |
| <b>Bellini, Claudio</b> .....19                            | <b>Bowman, Amanda</b> .....81                                   | <b>Candan, Onur</b> .....118                     |
| <b>Benson, Scott R.</b> ..19, 82, 92,<br>168               | <b>Bracho-Perez, Larry</b> 39, 101                              | <b>Carballo, Roberto</b> ..... 68                |
| <b>Benvenuti, Silvano</b> .....117                         | <b>Bradley, Adrian</b> .....92                                  | <b>Carruyo, Laura</b> .....101                   |
| <b>Bergmann, Charles</b> .....51                           | <b>Bradley, Stuart</b> .....33, 103                             | <b>Carter, Raquel</b> ..... 11                   |
| <b>Bergquist, Derk</b> .....20                             | <b>Braun-McNeill, Joanne</b> ...97                              | <b>Carter, Steven J.B.</b> ..114, 147            |
| <b>Beudard, Francois</b> .143, 153                         | <b>Bresett, Michael</b> .....60                                 | <b>Carthy, Ray R.</b> ..60, 71, 130,<br>157, 175 |
| <b>Bimbi, Melissa</b> .....20                              | <b>Briseño, Raquel</b> .....152                                 | <b>Casale, Paolo</b> .....40, 117                |
| <b>Bishop, Charles M.</b> .....128                         | <b>Broderick, Annette C.</b> ....67,<br>118, 154                | <b>Castilhos, Jaqueline C.</b> ... 80            |
| <b>Bjorndal, Karen A.</b> ....35, 37,<br>72, 100, 105, 171 | <b>Brogard, S.</b> .....130                                     | <b>Castillo-Leggs, V.</b> ..... 33               |
| <b>Blanco, Róger</b> .....34                               | <b>Bruno, Soraya C.</b> ...112, 123                             | <b>Castleberry, Steven B.</b> .... 25            |
| <b>Block, Barbara</b> .73, 130, 168                        | <b>Bryant, Amanda</b> .....60                                   | <b>Cayol, Claire</b> ..... 89                    |
| <b>Blumenthal, Janice</b> .....67                          | <b>Bui, Thi Thu Hien</b> .....140                               | <b>Cazabon, Michelle</b> ...68, 133              |
| <b>Blyde, David</b> .....98                                | <b>Buitrago, Joaquín</b> .....136                               | <b>Chacon, Didiher</b> .....160                  |
| <b>Boktok, Ketty</b> .....120                              | <b>Burchfield, Patrick M.</b> ....23                            | <b>Chaloupka, Milani</b> ....13, 36,<br>159      |
| <b>Bolaji, O.</b> .....165                                 | <b>Caceres, Celia</b> .....65                                   | <b>Chang, Rodolfo</b> .....177                   |
| <b>Bolten, Alan B.</b> ....35, 37, 72,<br>100, 151, 171    | <b>Cadrin, Steve</b> .....74                                    | <b>Chapman, Felicity</b> ..... 17                |
| <b>Bonatto, Sandro L.</b> ....79, 80                       | <b>Cahyani, Ni Kadek Dita</b> ..77                              | <b>Chapman, Tamra F.</b> ..... 2                 |
| <b>Bonner, Marny</b> .....1                                | <b>Calderon, Jairo</b> .....46                                  | <b>Chatto, Ray</b> .....2, 17, 170               |
| <b>Booth, David T.</b> .....3, 169                         | <b>Campbell, Cathi L.</b> ...68, 82,<br>83, 175, 177            | <b>Chaverri, Rebeca</b> ..... 64                 |
| <b>Bostwick, Angela</b> .....39                            | <b>Campbell, David</b> .....17                                  | <b>Cheng, I. Juinn</b> ..... 84                  |
| <b>Bothwell, John</b> .....67                              | <b>Campbell, Lisa M.</b> .....154                               | <b>Chokesanguan, Bundit</b> .. 40,<br>41         |
| <b>Bouquegneau, Jean-Marie</b><br>.....89                  | <b>Campos, Nelly de Paz</b> .....55                             | <b>Chu, Cuong The</b> .....3, 140                |

Author Index

- Ciccione, Stéphane**.....58, 66,  
70, 114, 115, 133, 143, 153
- Clark, Karen** .....57
- Coleman, Andrew**..... 115
- Coleman, Robin** .....68
- Coles, William** .....71
- Conruyt, Noël**.....58
- Conway, Shaun P.**.....4
- Corso, Gilberto** .....19
- Costa, Daniel** .....73
- Coyne, Michael S.**..... 118
- Cozens, Jacquie**.....21, 134
- Crowder, Larry** .....28, 138
- Cruz-Escalona, Victor H.**93
- D'Addario, Maristella** .....56
- Das, Krishna**.....89
- D'Auzon, Jean-Louis** .....135
- David, Charles** .....4, 80
- Davis, Patricia Z. R.** .....169
- Dawsey, Sarah**.....20
- Dawson, John** .....56
- de Abreu, João A. G.** .....24
- de Carvalho, Narciso A.** 170
- de Castilhos, Jaqueline C.**  
.....79
- de Paz, Nelly** .....46
- Dean, Christopher** .....29
- Debade, Xavier**.....177
- Debier, Cathy** .....89
- Delcroix, Eric** .....89
- Delgado, Cláudia**.....41, 96
- Delgado-Ortega, Gabriela**  
.....39
- Delisle, Aurelie**.....175
- Dellinger, Thomas**41, 42, 96
- Denham, John** .....126
- DePauw, Marie-Claire**.....89
- Desjardin, Niki**.....84
- Dethmers, Kiki**.....170
- Devadasan, Arvind** .....116
- Dharini, Supraja** ....135, 170
- Di Bello, Antonio**.....100
- Di Paola, Jose Luis**.....136
- Diaz, Javier Alvarado**.....85
- Diez, Carlos E.**.....73
- DiMatteo, Andrew** .....21
- DiMatteo, Salvatore**.....100
- Dimopoulos, Panayotis** ..128
- Dindo, John** .....115
- Dobbs, Kirstin** .....154
- Dodd, Mark G.**.....25
- Domingo, Andrés** .....122
- Donnelly, Marydele** .....42
- Dougherty, Erin** .....116
- Dow, Wendy E.**..... 88
- Downer, Ahab** ..... 24
- Doyle, Emma** .....136
- Drews, Carlos** ..... 55
- Drye, Bruce** ..... 60
- Duraisingham, Grace S.** 116
- Dutton, Peter H.**...65, 73, 79,  
81, 82, 84, 92, 93, 105,  
168, 171
- Dyc, Christelle** ..... 89
- Ebanks, Erik** .....103
- Ebanks-Petrie, Gina** ..... 67
- Eberdong, Joshua** .....125
- Echenique, Cintia**.....136
- Eckert, Scott A.**.....88, 112
- Edyvane, Karen** .....17, 170
- Eguchi, Tomoharu** ..43, 168,  
173
- Ehrhart, Llewellyn M.**... 60,  
84, 160
- Ekanayake, E.M. Lalith** 78,  
161
- Elshafie, Abdulkadir E.** 86,  
89, 95
- Enever, Gavin**..... 17
- Engstrom, Tag N.**..... 83
- Enstipp, Manfred**..... 66

|   |  |  |
|---|--|--|
| <b>Epperly, Sheryan P.</b> ...44, 51,<br>96 | <b>Forney, Karin</b> .....173                    | <b>Gaugne, Sophie</b> .....150                   |
| <b>Ernest, Robert</b> .....60               | <b>Forsberg, Kerstin S.</b> ...45, 65            | <b>George, Kevin</b> ..... 9                     |
| <b>Escobar, Erich</b> .....125              | <b>Foster, Claire</b> .....5                     | <b>Georges, Jean-Yves</b> ...66, 70              |
| <b>Espinoza, Ninive</b> .....101            | <b>Fournier, Sandy</b> .....60                   | <b>Gibb, James</b> ..... 67                      |
| <b>Estima, Sérgio C.</b> .....67            | <b>França da Silva, Janine<br/>Karla</b> .....42 | <b>Gibson, Janet P.</b> ..... 68                 |
| <b>Estrades, Andrés</b> .....137            | <b>Frazier, Jack</b> .....139                    | <b>Giffoni, Bruno</b> .....112                   |
| <b>Estrella</b> .....147                    | <b>Freggi, Daniela</b> .56, 100, 117             | <b>Gilardi, Kirsten V.</b> ..... 92              |
| <b>Evans, Samuel</b> .....17                | <b>Freire, Eliza M. X.</b> .....19               | <b>Gill, Bronwen</b> ..... 29                    |
| <b>Fabry, Mauricio</b> .....87              | <b>Frey, Amy</b> .....79, 81, 171                | <b>Glen, Fiona</b> .....118                      |
| <b>Fallabrino, Alejandro</b> ...122,<br>137 | <b>Frick, Michael</b> .....160                   | <b>Godfrey, David</b> .....22, 140               |
| <b>Fernandes, Luiza B.</b> .....80          | <b>Friday, Graeme</b> .....9, 17                 | <b>Godley, Brendan J.</b> ...65, 67,<br>118, 154 |
| <b>Fernandez, Carlos</b> .....126           | <b>Fritches, Kerstin A.</b> .....91              | <b>Gonzales, Catalina</b> .....177               |
| <b>Ferrando, Virginia</b> .....137          | <b>Frutchey, Karen</b> .....120                  | <b>Gonzalez Carmen, Victoria</b><br>..... 28     |
| <b>Ferreira, Betania</b> .....27, 137       | <b>Fuentes, Mariana MPB</b> ..56,<br>57, 155     | <b>González, Luis</b> .....177                   |
| <b>Ferreira, Telma</b> .....41              | <b>Fujioka, Ei</b> .....21                       | <b>Gravlee, Lance</b> .....175                   |
| <b>Ferris, Rochelle</b> .....1              | <b>Fuller, Wayne J.</b> .....118, 154            | <b>Grayson, Jillian</b> .....156, 176            |
| <b>Fico, Rosario</b> .....50                | <b>Gaffney, Phillip</b> .....52                  | <b>Grazziotin, Felipe G.</b> ..... 80            |
| <b>Finkbeiner, Elena</b> ...44, 138,<br>174 | <b>Gaines, Micahel S.</b> .....83                | <b>Grech, Alana</b> ..... 63                     |
| <b>Fish, Marianne R.</b> .....55            | <b>Galli, Silvia</b> .....117                    | <b>Greenland, Jenny</b> ..... 6                  |
| <b>FitzSimmons, Nancy</b> ....5, 80         | <b>Gamblin, Paul</b> .....11                     | <b>Griffin, Elizabeth</b> .....44, 46            |
| <b>Flanagan, Joe</b> .....96                | <b>Gardner, Susan C.</b> .....93, 94             | <b>Griffin, Ken</b> ..... 6                      |
| <b>Flint, Mark</b> .....90, 98              | <b>Garland, Katy</b> .....175                    | <b>Grigg, Gordon C.</b> .....102                 |
| <b>Floeter, Sergio R.</b> .....24           | <b>Garrison, Lance P.</b> .....44                | <b>Grimes, Jim</b> ..... 35                      |
| <b>Formia, Angela</b> .....27, 137          | <b>Gaspar, Cécile</b> .....139                   | <b>Grizel, Henri</b> ..... 66                    |
|   | <b>Gaston, Jason</b> .....1                      | <b>Guada, Hedely J.</b> .....136                 |

Author Index

- Guerra, Carlos .....87
- Guerreri, Christian L.....57
- Guertin, Jeffrey ..... 118
- Guiducci, Simonetta .....50
- Guinea, Michael L. ....4, 7
- Hadden, Kate .....17
- Hahn, Anelise Torres.79, 80
- Halkyard, Brooke .....11
- Hall, Martin A.....46
- Halpin, Pat .....21
- Hamann, Mark .4, 6, 18, 56,  
57, 63, 80, 155, 156, 176
- Hancock, Joana M. ....160
- Handy, Scott.....36
- Harfush, Martha.....34
- Harms, Craig A.....88
- Harris, Heather S. ....92
- Harrison, Emma .....22, 126,  
140, 177, 179
- Hartley, Simon .....17
- Hataway, Dominy .....51
- Haxhiu, Idriz.....152, 166
- Hays, Graeme C.....128
- Helmbrecht, S'rai .....174
- Hernández, Yorman .....39
- Hess, Lauren ..... 156
- Higgins, Benjamin M.....39,  
51, 96, 129
- Hill, Fiona.....52
- Hillis-Starr, Zandy ...22, 25,  
82
- Hirshfield, Michael .....46
- Hitipeuw, Creusa .....19, 168
- Hodge, Mary .....104
- Holford, Sherida .....17
- Holloway-Adkins, Karen G.  
.....69
- Hopkins-Murphy, Sally R.  
.....106
- Horner, Amy J. ....121
- Horoku, Joe .....19, 168
- Horrocks, Julia A.....82
- Hosono, Takashi .....119
- Howell, Lyndsey N.....69
- Howlett, Kelly .....7
- Hu, Fuxiang.....51
- Hughes, George R.....107
- Hykle, Douglas .....141
- Ibrahim, Kamarruddin .104
- Ibrahim, Mahmoud .....54
- Ikonomopoulou, Maria P.  
.....92
- Ilukewitsch, Vanesa .....101
- Inoguchi, Emi.....32
- Irwin, William P. ....144
- Isely, J. Jeffery ..... 77
- Ishihara, Takashi .....23, 75
- Isimeli, Fesi.....178
- Islam, Mohammad Z. .... 47
- Isvaran, Kavita..... 59
- Jacobson, Susan .....175
- Jamaludin ..... 32
- Jean, Claire 58, 70, 115, 133
- Jensen, Michael ..... 80
- Jit, Joytishna .....141
- Jobsis, Paul .....142
- Johnson, Chris .....60, 99
- Johnson, Stephen ..... 17
- Johnson, Steve..... 9
- Jolon, Mario ..... 46
- Jones, David ..... 64
- Jones, Michelle .....8, 17
- Jones, T. Todd..... 88
- Jourdan, Vie .....139
- Joyson-Hicks, Catharine  
.....48, 156
- Jue, Amy K..... 81
- Kabua, Emma .....120
- Kamal, Abu Hena M..... 59
- Kamezaki, Naoki.....23, 75

|   |  |   |
|---|--|---|
| <b>Kapurusinghe, Thushan</b> 78, 161          | <b>Kunjappan, Rejani</b> .....167            | <b>Limpus, Colin J.</b> 3, 5, 24, 36, 56, 57, 63, 90, 98, 102, 108, 131 |
| <b>Kar, Chandrasekhar</b> .....59             | <b>Kwan, Donna</b> .....154, 156             | <b>Limpus, Duncan J.</b> ..... 5  |
| <b>Karagouni, Amalia D.</b> ....29, 30, 121   | <b>Labrada-Martagón, Vanessa</b> .....93, 94 | <b>Lira-R., Diana J.</b> ..... 23                                       |
| <b>Karnad, Divya</b> .....59                  | <b>LaCasella, Erin L.</b> 79, 81, 82         | <b>Llorente, Adolfo Marco.</b> 127                                      |
| <b>Katselidis, Kostas A.</b> 29, 30, 121, 128 | <b>Lagueux, Cynthia J.</b> ...82, 83, 177    | <b>Loban, Frank</b> ...4, 9, 16, 179                                    |
| <b>Kaylor, Michelle</b> .....144              | <b>Lalara, Simeon</b> .....17                | <b>Lockhart, Gwen</b> ..... 53  |
| <b>Keller, Jennifer M.</b> .....97            | <b>Landry, Jr., André M.</b> ....39, 69, 129 | <b>Lohmann, Catherine M. F.</b> .....121                                |
| <b>Kemler, Erika</b> .....144                 | <b>Langidrik, Matylene</b> .....120          | <b>Lohmann, Kenneth J.</b> ....121                                      |
| <b>Kendrick, Alan</b> .....2                  | <b>Larsen, Libby</b> .....9, 17              | <b>Lombana, Alfonso</b> ..... 55  |
| <b>Kennett, Rod</b> .....9                    | <b>Lau, Min Min</b> .....116                 | <b>Long, Jack</b> ..... 17  |
| <b>Khan, T.</b> .....87                       | <b>Lauder, Anderson</b> .....17              | <b>Longo, Guilherme O.</b> ..... 24                                     |
| <b>Kimmel, Tricia</b> .....97                 | <b>Lauret-Stepler, Marie</b> ..143, 153      | <b>Lopez, Gustave G.</b> .....123                                       |
| <b>Kinan Kelly, Irene</b> .....164            | <b>Laveti, Merewalesi</b> 157, 178           | <b>López, Melania</b> ..... 94  |
| <b>Kiyota, Masashi</b> .....119               | <b>Layton, Jenny Estes</b> .....60           | <b>López-Castro, Melania C.</b> .....171                                |
| <b>Kleidon, Anthony</b> .....17               | <b>LeBlanc, Anne M.</b> .....23              | <b>López-Mendilaharsu, Milagros</b> .....122                            |
| <b>Klein, Warren</b> .....27, 137             | <b>Leclerc, Nicolas</b> .....139             | <b>Lowell, Beth</b> ..... 46  |
| <b>Koch, Volker</b> ....48, 130, 172          | <b>Lee, Shing Yip</b> .....104               | <b>Lucas, Sarah</b> ..... 36  |
| <b>Koepfler, Eric</b> .....36                 | <b>Lennert-Cody, Cleridy</b> ....46          | <b>Lundgren, Ian F.</b> .....22, 25                                     |
| <b>Komoroske, Lisa</b> .....93                | <b>LeRoux, Robin A.</b> 79, 81, 82           | <b>Luschi, Paolo</b> .....117   |
| <b>Kouris, Stephanos.</b> 152, 166            | <b>Lewis, Amy</b> .....11                    | <b>M'soili, Anfan</b> .....143  |
| <b>Kregor, Geoff</b> .....14                  | <b>Lewis, Kemit-Amon.</b> 71, 142            | <b>Macgregor, Kate</b> ..... 11   |
| <b>Kreutz, David</b> .....127, 162            | <b>Lewison, Rebecca</b> .....93              | <b>MacKay, Kenneth.</b> 157, 178  |
| <b>Krueger, Barry</b> .....19                 | <b>Ligas, Alessandro</b> .....50             | <b>Maclean, Cath</b> ..... 6  |
| <b>Kuchling, Gerald</b> .....60               | <b>Lima, Eduardo H.S.M.</b> ..123            |   |

Author Index

- Magun, Wenceslaus ..... 162
- Mahardika, IGNK ..... 77
- Mahmoud, Ibrahim Y. ... 86,  
87, 89, 95
- Maier, Philip P. .... 77
- Maison, Kimberly ..... 61
- Maldonado-Diaz, David .. 73
- Mancini, Agnese ..... 48, 172
- Manderson, Ethan ..... 103
- Mangel, Jeffrey ..... 65
- Mann, David A. ... 88, 95, 124
- Manolis, S. Charlie .. 98, 125
- Marco, Adolfo ..... 28, 61
- Marcovaldi, Maria Â. .... 123
- Margaritoulis, Dimitris .. 29,  
163
- Marin, Alicia ..... 144
- Marion, Ken ..... 115
- Marmoex, Cyril ..... 143, 153
- Márquez-Almansa, P. .... 33
- Marrón Fiol, J. .... 33
- Marrón Fiol, R. .... 33
- Marsh, Helene ..... 10, 176
- Marshall, Greg J. .... 131
- Martin, Kelly J. .... 95, 124
- Martin, R. Erik ..... 60, 84
- Martinez-O., Hector J. .... 23
- Martins, António Jorge .. 42,  
96
- Masuda, Akiko ..... 83
- Mathias, Sarah ..... 144
- Mau, Roland ..... 11
- Mazet, Jonna A.K. .... 92
- Mazzarella, Kristen . 35, 113
- Mbendo, Jane R. .... 143
- Mbugani, John ..... 156
- McCracken, Marti L. .... 39
- McElroy, Mandi L. .... 25
- McFarlane, Glenn C. .... 12
- McMichael, Erin ..... 71, 96
- Meciani, Nicola ..... 50
- Medina, Yosvani ..... 125
- Megill, William ..... 130
- Melero, David ..... 36
- Meletis, Zoe A. .... 179
- Mencacci, Resi ..... 117
- Mendes, Edson ..... 21
- Méndez-Rodríguez, Lia .. 93,  
94
- Menon, Manju ..... 149, 173
- Merrill, Maria W. .... 124
- Meschini, Paola ..... 117
- Metcalfe, Janene ..... 8
- Meylan, Anne ..... 126
- Meylan, Peter ..... 126
- Miles, Rachel ..... 21
- Mille, Bob ..... 26
- Miller, Debra L. .... 99
- Miller, Jeannie ..... 144
- Miller, Philip ..... 122
- Mills, Harriet ..... 5
- Mills, Paul C. .... 90, 98
- Minami, Hiroshi ..... 119
- Mituhasi, Takahisa ..... 46
- Miyauchi, Kano ..... 75
- Moersch, Chris ..... 103
- Moloney, James M. .... 57, 63
- Moncada, Félix ..... 125
- Monteiro, Danielle S. .... 67
- Montiel-Villalobos, Maria  
Gabriela .. 39, 49, 101, 113
- Moore, Jeffrey ..... 44
- Morin, Phillip A. .... 84
- Moro, Dorian ..... 5, 12
- Morris, Keith ..... 2
- Mortimer, Jeanne A. .... 109
- Morton, John ..... 90
- Mosqueira, Flor de Maria  
Gomez ..... 27
- Mota, Mario J. .... 157
- Moth-Poulsen, T. .... 165

|   |  |  |
|---|--|--|
| <b>Mott, Cody</b> .....118                    | <b>O'Hara, Amanda</b> .....103                 | <b>Patterson-Kane, Janet C.</b><br>.....90, 98 |
| <b>Mounier, Sophie</b> .....24                | <b>Okazaki, Makoto</b> .....119                | <b>Pazeto, Fernando D.</b> ..... 24            |
| <b>Mug, Moises</b> .....46                    | <b>O'Keefe, Kelly</b> .....144                 | <b>Peavey, Lindsey</b> ..... 28                |
| <b>Murray, Peter J.</b> .....90               | <b>Olynik, Jeremy</b> .....67                  | <b>Peckham, S. Hoyt</b> .....73, 173           |
| <b>Murray, Tonya</b> .....9                   | <b>Onton, Kim</b> .....11                      | <b>Pena-V., Jaime</b> ..... 23                 |
| <b>Muurmans, Maggie</b> .....144              | <b>Opurum, S. C.</b> .....165                  | <b>Pendoley, Kellie</b> .....5, 13, 159        |
| <b>Nahill, Brad</b> .....138                  | <b>Ordoñez, Cristina</b> .....126              | <b>Pennober, Gwenaëlle</b> ..... 58            |
| <b>Nairn, Campbell J.</b> .....84             | <b>Orimogunje, O.</b> .....165                 | <b>Pereira, Manuel</b> ..... 21                |
| <b>Namboothri, Naveen</b> .....31             | <b>Orr, Mark</b> .....67                       | <b>Perez, Elena Abella</b> .....127            |
| <b>Nand, Neema</b> .....157                   | <b>Orrego, Carlos Mario</b> .....34            | <b>Perez, Sara</b> ..... 46                    |
| <b>Nash, Rachael</b> .....125                 | <b>Ortega, David</b> .....46                   | <b>Perkins, Susan</b> .....103                 |
| <b>Nel, Ronel</b> .....158                    | <b>Ouellette, Stefanie A.</b> .....144         | <b>Perrault, Justin</b> ..... 99               |
| <b>Nelson, David</b> .....115                 | <b>Owens, David W.</b> .....38                 | <b>Petit, Matthieu</b> .....139                |
| <b>Ngatunga, Ben</b> .....48                  | <b>Pacheco, Lucas</b> .....46                  | <b>Petritaj, Lazion</b> .....152, 166          |
| <b>Nichols, Wallace J.</b> ...73, 130,<br>138 | <b>Pajuelo, Mariela</b> .....72                | <b>Petro, George</b> .....145                  |
| <b>Nielsen, Janne T.</b> .....83              | <b>Palacios, Daniel P.</b> .....130            | <b>Pham, Tuan Hung</b> .....140                |
| <b>Nodarse, Gonzalo</b> .....125              | <b>Paladino, Frank</b> .....130                | <b>Phillott, Andrea D.</b> .....172            |
| <b>Nogueira, Antonio</b> ...27, 137           | <b>Palaniappan, Pushpa M.</b> .98              | <b>Piedra, Rodney</b> .....130                 |
| <b>Nolasco, Dagnia</b> .....177               | <b>Panagopoulou, Alik</b> .....163             | <b>Pikacha, Patrick</b> ..... 19               |
| <b>Norton, Terry M.</b> .....144              | <b>Pantis, John D.</b> .....128                | <b>Pike, David A.</b> ..... 62                 |
| <b>Oades, Daniel</b> .....9                   | <b>Papetti, Luana</b> .....50                  | <b>Pilcher, Nicolas J.</b> .....164            |
| <b>Oates, Jessica</b> ..... 13, 159           | <b>Parga, MariLuz</b> .....46                  | <b>Pinto, Ana</b> .....103                     |
| <b>Ochoa, Ruth</b> .....73                    | <b>Parker, Denise</b> .....120                 | <b>Pita, John</b> .....19, 168                 |
| <b>O'Connell, Steven G.</b> .....97           | <b>Parrales, Manuel</b> .....46                | <b>Plantalech Manel-la, Núria</b><br>.....127  |
| <b>Ogbonna, J. C.</b> .....165                | <b>Patiño-Martínez, Juan</b> ...28,<br>61, 127 | <b>Poche', Billie</b> .....101                 |

Author Index

- Polovina, Jeffery .....73
- Poppenga, Robert H .....92
- Possardt, Earl.....23
- Pracy, Damian .....17
- Premakumara, M.G.C. ....78
- Prince, Robert I.T.....14
- Pritchard, Peter C. H. ...110
- Priyono, Agus.....32
- Prosdocimi, Laura .....122
- Provancha, Jane A.....69
- Putra, Ketut Sarjana .....77
- Quaranta, Angelo .....100
- Quiñones Davila, Javier  
Antonio .....55
- Quiñones, Liliana.....28, 61
- Rajakaruna, R.S. ....78
- Ramanathan, Anand .....65,  
137, 161
- Ramohia, Peter .....19, 168
- Ramos, Mario.....152
- Ranawana, K.B. ....78
- Rangel, Rodrigo .....173
- Ranger, Sue .....154
- Rathnakumara, Saman .161
- Read, Andy.....21
- Read, Mark .....164
- Read, Tyffen Chloé.....63
- Redfoot, William .....160
- Rei, Vagi .....19, 168
- Reich, Kimberly J.....100
- Reina, Richard D. ....65
- Rendon, Liliana.....46
- Reyes Sánchez, Agustín .151
- Reyes, Ricardo Borquez 172
- Richards, Susan .....17
- Rieser, Alison .....146
- Rincon, Robert.....101
- Rincón-Díaz, Patricia .....73
- Rivera, Gabriel .....116
- Rivero, Libicni .....101
- Roberts, Chris .....9
- Robertson, Ian.....33, 103
- Robins, Carolyn .....127
- Robinson, Prue.....152, 166
- Rocha, Carlos F.D.....122
- Rochester, Wayne.....131
- Roden, Suzanne E.....81, 82,  
84
- Roder, Christian .....146
- Rodriguez, Sudarshan..147,  
149
- Rosenbaum, Howard.....27,  
137
- Ross, Perran .....111, 175
- Rueda, Lucia .....74
- Rumano, Merita.....152, 166
- Sabat, Alberto .....73
- Saçdanaku, Enerit .152, 166
- Sagarminaga, Ricardo....74
- Sailor, Eddie .....9
- Sainz, Noa .....169
- Salmon, Michael.....18, 118,  
124
- Saman, M.M.....78, 161
- Samaraweera, P. ....78
- Samber, Betuel.....19, 168
- Samson, Catherine.....11
- Sanchez, Regina .....46
- Sankaran, S. ....33, 147
- Santana Garcon, Julia....63
- Santos, Fabricio R.....85
- Santurtun, Eduardo.....137
- Saravia, Victoria .....29
- Sarti, Laura .....132
- Sasso, Christopher R. ....160
- Scalfoni, Juarez T. ....112
- Scaravelli, Dino .....117
- Scarpino, Russell A.....71
- Schaffer, Chuck .....148
- Schaffer, Rick.....148

|  |   |  |
|--|---|--|
| <b>Schmid, Jill</b> .....60                            | <b>Smith, Lauren E.</b> .....101              | <b>Takeuchi, Yuka</b> ..... 75                                 |
| <b>Schmidt, Robert H.</b> .....180                     | <b>Snider, Richard</b> .....76                | <b>Tanaka, Shinichi</b> ..... 32                               |
| <b>Schofield, Gail</b> ...29, 30, 121,<br>128          | <b>Snover, Melissa L.</b> .....75, 165        | <b>Tapilatu, Ricardo</b> .....19, 168                          |
| <b>Schroeder, Barbara</b> ...23, 97                    | <b>Soares, Luciano S.</b> .....79, 85,<br>123 | <b>Tavera, Gloria</b> ..... 23                                 |
| <b>Scott, Tara L.</b> .....50                          | <b>Solarin, Bolu</b> .....165                 | <b>Tayalé, Alexandre</b> .....150                              |
| <b>Secchi, Eduardo R.</b> .....67                      | <b>Solomon, Joni</b> .....67                  | <b>Templeton, Robert</b> .....130                              |
| <b>Segars, Al L.</b> .....38, 97                       | <b>Sourbes, Laurent</b> 29, 30, 121           | <b>Thomé, Jean-Pierre</b> ..... 89                             |
| <b>Segura, Alvaro</b> .....46                          | <b>Speirs, Marissa</b> .....2, 14             | <b>Thomé, João Carlos A.</b> ...112                            |
| <b>Seminoff, Jeffrey A.</b> ...65, 71,<br>72, 172, 173 | <b>Spencer, Peter</b> .....103                | <b>Thompson, Larry J.</b> ..... 99                             |
| <b>Seney, Erin E.</b> .....129                         | <b>Sperling, Jannie B.</b> .....102           | <b>Thwaites, Andrew</b> ..... 52                               |
| <b>Senko, Jesse</b> .....130                           | <b>Spotila, James</b> .....130                | <b>Tiburcio-Pintos, G.</b> ...33, 147                          |
| <b>Shamblin, Brian M.</b> .....84                      | <b>Sridhar, Aarthi</b> .....147, 149,<br>173  | <b>Tiwari, Manjula</b> .....151                                |
| <b>Shanker, Kartik</b> ..31, 34, 59,<br>149            | <b>Stanley, Fran</b> .....2, 14               | <b>Tokai, Tadashi</b> ..... 51                                 |
| <b>Shaver, Donna J.</b> .....69                        | <b>Steckenreuter, Andre</b> .....30           | <b>Tordoir, Mark T.</b> ..... 27                               |
| <b>Shelb, Stephen M.</b> .....76                       | <b>Stokes, Lesley W.</b> .....44, 51          | <b>Townsend, Kathy A.</b> ..... 53                             |
| <b>Shenoy, Seema</b> .....149, 173                     | <b>Strydom, Aub</b> .....15                   | <b>Trapani, Christina</b> ..... 53                             |
| <b>Shiga, Michiru</b> .....51                          | <b>Subramaniam, Devi</b> .....31              | <b>Trejo, Carlos Delgado</b> .. 85                             |
| <b>Shillinger, George</b> .....130                     | <b>Suganuma, Hiroyuki</b> 32, 119             | <b>Tremblay, Yann</b> ..... 73                                 |
| <b>Shimada, Takahiro</b> .....75                       | <b>Sullivan, Mark S.</b> .....165             | <b>Tripathy, Basudev</b> ..... 34                              |
| <b>Shiode, Daisuke</b> .....51                         | <b>Sunderraj, S.F. Wesley</b> ...31           | <b>Trocini, Sabrina</b> .....33, 103                           |
| <b>Simon, Thomas</b> .....17                           | <b>Sutherland, Lachlan</b> ..9, 179           | <b>Troëng, Sebastian</b> ..... 82                              |
| <b>Siriraksophon, Somboon.</b> 41                      | <b>Swingle, Mark</b> .....53                  | <b>Tsaros, Paul</b> .....163                                   |
| <b>Sirna, Riccardo</b> .....50, 117                    | <b>Swithenbank, A.</b> .....130               | <b>Tubbs, Mollie E.</b> ..... 76                               |
| <b>Smith, Kristin</b> .....26                          | <b>Syamsuni, Yuliana Fitri</b> ..32           | <b>Tucker, Anton D.</b> ..5, 34, 35,<br>60, 113, 118, 124, 131 |
|  | <b>Sybert, David M.</b> .....57               | <b>Turner, Malcolm</b> .....164                                |

Author Index

|   |   |   |
|---|---|---|
| <b>Urrutia Fucugauchi, Jaime</b><br>.....85 | <b>Waayers, David A.</b> .....11, 15        | <b>Witt, Matthew J.</b> .....154                    |
| <b>Vadillo, Miriam C.</b> .....103          | <b>Wailu, Moses</b> .....16                 | <b>Wood, Charles</b> .....175                       |
| <b>Vaidyanathan, Tanvi</b> .....173         | <b>Wallace, Bryan</b> ..21, 44, 130,<br>174 | <b>Wood, Lawrence D.</b> ..... 76                   |
| <b>Valqui, Michael</b> .....46              | <b>Walsh, Vanessa</b> .....9                | <b>Work, Thierry M.</b> ..... 92                    |
| <b>Valverde, Roldán A.</b> .27, 34,<br>101  | <b>Warneminde, Leigh</b> .....17            | <b>Wrege, Beth M.</b> ..... 77                      |
| <b>van Dam, Robert</b> .....73              | <b>Warren, Kristin</b> .....103             | <b>Wright, Laura</b> ..... 84                       |
| <b>van de Merwe, Jason</b> .....104         | <b>Watson, Kennard</b> .....60              | <b>Wright, Lisa</b> ..... 53                        |
| <b>van der Wal, Edith S.</b> .....35        | <b>Webb, Grahame J.W.</b> .....98,<br>125   | <b>Wurlanty, Bas</b> ..... 19                       |
| <b>van der Wal, Richard W.</b> 35           | <b>Weiss, Kristen C.</b> .....9, 180        | <b>Wyneken, Jeanette</b> ....18, 60,<br>96, 99, 116 |
| <b>van der Wal, Sietske M.</b> ..35         | <b>Welsh, Ryan</b> .....35                  | <b>Xiques, Rebecca A.</b> ..... 36                  |
| <b>Van Houtan, Kyle S.</b> .....64          | <b>White, Michael</b> .....152, 166         | <b>Yunupingu, Balapulu</b> ..... 9                  |
| <b>Vander Zanden, Hannah B.</b><br>.....35  | <b>Whiting, Andrea U.</b> .....36           | <b>Yusuf, Akil</b> .....32, 119                     |
| <b>Vargas, Sarah M.</b> .....85             | <b>Whiting, Scott D.</b> .....17            | <b>Zainudin, Imam M.</b> ..... 54                   |
| <b>Vásquez Ruiz, Floriberto</b><br>.....151 | <b>Whittier, Joan</b> .....92, 104          | <b>Zamani, Neviaty P.</b> ..... 32                  |
| <b>Velez-Zuazo, Ximena</b> .....77          | <b>Wibbels, Thane</b> ..23, 60, 115         | <b>Zapata, Luis</b> ..... 46                        |
| <b>Venizelos, Lily</b> .....152, 166        | <b>Wilcox, Chris</b> .....131               | <b>Zárate, Patricia M.</b> ....37, 84               |
| <b>Verissimo, Diogo</b> .....64             | <b>Wildermann, Natalie</b> .....101         | <b>Zavala, Alan A.</b> .....152                     |
| <b>Villavicencio, Jorge</b> .....46         | <b>Williams, Keith</b> .....1               | <b>Zeballos Flor, Jorge A.</b> ... 55               |
| <b>Vitucci, Giuseppe</b> .....100           | <b>Williams, Kristina</b> .....160          | <b>Zenteno-Savín, Tania</b> 93, 94                  |
| <b>Vogel, Nickolas</b> .....46              | <b>Williams, Marcus</b> .....103            | <b>Zulkifli, Rahayu</b> .....167                    |
|   | <b>Wiradnyana, I Wayan</b> ...167           | <b>Zurita, Julio</b> .....160                       |