NOAA Technical Memorandum NMFS-SEFSC-640

PROCEEDINGS OF THE THIRTIETH ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION

24–30 April 2010
Goa, India

Compiled by:
Janice Blumenthal, Aliki Panagopoulou, and ALan F. Rees

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
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PRESIDENT'S REPORT

30th Annual Symposium on Sea Turtle Biology and Conservation
24 – 30 April, 2010, Goa, India

Kartik Shanker

President, International Sea Turtle Society
Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012, India.
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For the first time in 30 years, the International Sea Turtle Society's Annual Symposium was held in south Asia, a region home to globally significant populations of marine turtles, and a diverse range of organisations, community based groups and institutions involved in sea turtle research and conservation. The symposium provided an excellent opportunity to participants from countries in South and Southeast Asia to attend the event. The theme of the symposium '*the world of turtles*' drew attention to the wide range of ecosystems that sea turtles inhabit including coastal, nearshore and oceanic ecosystems, from sandy beaches to coral reefs and seagrass meadows, and pelagic habitats. An important focus of the symposium was also to draw attention to the human communities that sea turtles interact with, in particular resource dependent coastal fishing communities.

With over 500 participants from over 60 countries, the success of the symposium was reflected in the coming together of ideas in research and lessons in conservation from a diverse range of individuals and groups, both at the local and regional / global scale. Over 400 abstracts were received and a total of 376 were presented after a careful review process by the Programme Committee, overseen by Programme Chairs Matthew Godfrey and Brendan Godley and the Programme Coordinator DuBose Griffin. The symposium was held at the Kala Academy in Panaji, Goa's renowned centre for performing arts, situated on the banks of the Mandovi River. A few workshops were also held at the Taj Vivanta Hotel situated across the road from the Kala Academy. All evening social events were held at the Cidade de Goa hotel at Vainguinim beach in Dona Paula.

Pre-symposium meetings and workshops commenced on 24 April and included workshops on: Marine Invasive Species, Bayesian Statistics, Stable Isotopes and Conservation of Marine Turtles and Dugongs. Regional meetings including the Indian Ocean and Southeast Asia, Africa, Mediterranean and Latin America (RETOMALA) meetings were held on the three days prior to the symposium. Workshops on Satellite Telemetry and Turtle Rehabilitation, and the IUCN SSC Marine Turtle Specialist Group – Annual General Meeting were held on 30 April. Two special meetings were held at this year's symposium: the Fisheries Forum on 25April and the South Asia Mini-Symposium on 26 April. The main symposium sessions were held between 27-29 April at the Kala Academy, with parallel sessions running at the adjacent hall within the Academy complex. Symposium session titles, which were intended to reflect the theme of the symposium included: Ecosystem function, Conservation and Management, Foraging Biology, Fisheries and Bycatch, Health and Physiology, Research in Social Science, Environmental Impacts, Reproduction Biology, and Migration and Navigation. There were 119 oral, 30 speed (oral) and 222 poster presentations during the symposium. Dedicated "meet the author" poster sessions were held between 3:30 and 4:00 pm on 27 and 28 April.

The ISTS President's Award to an organization was presented jointly to the Trust for Environmental Education (TREE Foundation) and the Students' Sea Turtle Conservation Network in recognition of their work on sea turtle conservation in south India. The individual awards went to Saw Agu in recognition of his work on sea turtle monitoring and conservation in the Andaman and Nicobar Islands, to Kalakar 'Kalia' Behera and Dambarudhara Behera in recognition of their work on sea turtle monitoring and conservation in Orissa. The ISTS Champion's Awards were presented to Daniel William, in recognition of his contributions and lasting impact on sea turtle conservation in French Guiana, Satish Bhaskar, in recognition of his pioneering surveys and research on sea turtles in South and Southeast Asia and the Turtle Conservation Project, Sri Lanka, in recognition of their contribution to sea turtle conservation and their work with coastal communities in Sri Lanka. The ISTS Lifetime Achievement Award was presented to Dimitris Margaritoulis for his significant impact on sea turtle biology and conservation through the course of his career.

The ISTS raised $ 113,700 towards travel grant support this year. $ 49,916 was disbursed as cash awards to172 participants and free accommodation for the entire duration of the symposium was provided to 327 participants, the most at any symposium thus far. The tireless efforts of Hoyt Peckham (Travel Chair) and the regional travel chairs made sure that all deserving participants could avail of the travel award. The regional travel committee comprised of Aliki Panagapolou (Europe), Angela Formia and Manjula Tiwari (Africa), Nicolas Pilcher (Asia/Pacific), Karen Eckert (Caribbean), Alejandro Fallabrino (Latin America), Kartik Shanker (India/South Asia) and Bryan Wallace (USA/Canada).

With over 250 participants from India, and 53 from our neighbouring countries of Sri Lanka, Myanmar, Bangladesh and Pakistan, this year's symposium achieved one of its primary objectives, that of enabling the participation of as many individuals as possible from the region. The registration fee for students and the low-income category was substantially reduced, and travel grants were provided to support travel of as many as 80 participants from south Asia (including India). Unique to this year's symposium was the range of partner organisations that helped to host the event. The Turtle Conservation Project in Sri Lanka, Marine Life Alliance and Centre for Advanced Research in Natural Resources and Management (CARINAM) in Bangladesh, WWF-Pakistan and Marine Research Centre in Maldives were regional partners at the event. Over 25 organisations in India partnered in the event. The National Centre for Biological Sciences, FERAL, the Centre for Ecological Sciences at the Indian Institute of Science and Dakshin Foundation contributed significantly to the planning and hosting of the event.

The International Sea Turtle Society and the local organizing committee is grateful to the support provided by our international donors and sponsors, including many of our annual sponsors who supported us despite the economic recession. In particular, we thank the Western Pacific Regional Fishery Management Council (WestPac), the Marine Turtle Conservation Act Fund of the US Fish and Wildlife Service, National Oceanographic and Atmospheric Administration (NOAA, USA), NAILSMA and Disney's Animal Programs for support towards travel and accommodation grants provided to grant recipients. Wildlife Computers, Sirtrack, Telonics and the UNEP – Abu Dhabi provided support towards associated workshops and regional meetings.

The Ministry of Environment and Forests contributed our largest grant this year. The Council for Scientific and Industrial Research and the Departments of Science and Technology and Biotechnology, the State Government of Goa and the Goa Tourism Development Corporation Ltd. were also key supporters and sponsors of the event.
Our major corporate sponsors included Reliance Industries Ltd., USV Limited, Sesa Goa, the Indian Farmers Fertilisers Cooperative Ltd (IFFCO), Ambuja Cements and ABG Shipyard. Institutions and organizations that provided generous donations included National Centre for Biological Sciences, Navajbai Ratan Tata Trust, Fishery Survey of India, South Asia Cooperative Environment Programme (SACEP), Ashoka Trust for Research in Ecology and the Environment, Vasanth J. Sheth Memorial Foundation and Foundation for Ecological Security. Our tea and coffee break sponsors included EID Parry (India) Ltd., Unibic India and CLS-America. We are also grateful to various individuals who contributed through room and coffee break sponsorships. In particular we thank Kellie Pendoley, Nancy FitzSimmons and Wildlife Computers for their generous contributions towards room sponsorships.

Several individuals contributed countless hours of time and effort to ensure the success of this symposium. Aarthi Sridhar and Meera Anna Oommen were instrumental in raising funds for the event and overseeing organizational aspects. Individual contributions from Anand Pakkurti, Chico D'Lima, Donna Kwan, Elena Finkbeiner, M.M. Venkatachalam, Michael D'Souza and Wesley Sunderraj towards raising funds from various sources deserve special thanks. Maya Ramaswamy & Arjun Shanker provided beautiful artwork and design for the symposium. The students at the Centre for Ecological Sciences made a fantastic team and ensured that the programme went off without a glitch. BC Choudhury and Jack Frazier guided the entire symposium, and Brendan Godley and Matthew Godfrey chaired the programme. Michael Coyne and Manjula Tiwari were stellar in their roles as always, and all my colleagues at the ISTS supported us in conducting a successful symposium. Finally, we thank Seema Shenoy and Naveen Namboothri for being the backbone of all the planning and execution for the symposium.

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Edwin B. Drane, ISTS Treasurer for more than two decades passed away on 6 August 2009. The ISTS deeply regrets the loss.

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South Asia Mini-Symposium	Ahmed Khan, Basudev Tripathy, B.C. Choudhury, Hussein Zahir, Naveen Namboothri, S.M.A. Rashid and Thushan Kapurusinghe
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Statistics Workshop	Jagdish Krishnaswamy and Kavita Isvaran
Marine Invasive Species Workshop	Rauf Ali
Stable Isotope Techniques Workshop	Bryan Wallace, Jeffrey Seminoff, Karen Arthur and Kim Reich
Marine Turtle and Dugong Conservation Workshop	Donna Kwan and Jenny Renell
Rescue and Rehabilitation Workshop	Antonio de Bello and Daniela Freggi
Satellite Telemetry Workshop	Catherine McClellan, Larisa Avens and Tony Tucker
Sea Turtle Genetics Meeting	Nancy Fitzsimmons
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STUDENT PRESENTATION AWARDS 2010

A long-standing tradition at the International Sea Turtle Symposium, Archie Carr Awards for best student presentations were given to eight students. An international team of judges reviewed all 109 student presentations, and selected the eight presentations below for the highest level of research and excellent presentation. In keeping with the Symposium's international perspective, awards were given to students from seven different countries locataed on four different continents.

Best Poster – BIOLOGY
Itzel Sifuentes-Romero, UNAM, Mexico
Expression of SOX9 and HOX genes in the embryonic reproductive tract of *Lepidochelys olivacea* during sex determination.

Runner up Poster – BIOLOGY
Rubén E. Venegas-Li, Fundacion Keto and University of Costa Rica, Costa Rica
Correlation of loggerhead turtle nesting numbers in Zakynthos with the sea surface temperature at this population's feeding grounds

Best Poster – CONSERVATION
Satya R. Behara, Wildlife Institute of India, India
Impact of erosion on hatching success in mass nesting sites of olive ridley along the Orissa coast, India coast, India

Runner up Poster – CONSERVATION
Ohiana Revuelta, University of Valencia, Spain
Evaluation of conservation measures for hawksbills (*Eretmochelys imbricata*) nesting in the Dominican Republic

Best Oral Presentation – BIOLOGY
Guilherme O. Longo, Universidade Federal de Santa Catarina, Brazil
Reproductive periodicity and abundance estimates of green turtle adult males at Atol das Rocas Marine Biological Reserve, NE Brazil

Runner up Oral Presentation – BIOLOGY
Catherine McClellan, Duke University, USA
Staple isotopes and telemetry reveal life history dichotomy in juvenile loggerhead sea turtles

Best Oral Presentation – CONSERVATION
Joanna Alfaro Shigueto, University of Exeter, UK
Use of innovative tools for at-sea outreach: radio conservation for at-sea decision makers

Runner up Oral Presentation – CONSERVATION
Katy Garland, University of Florida, USA
Changing taste preferences, market demands and traditions in Pearl Lagoon, Nicaragua: a community reliant on *Chelonia mydas* for income and nutrition

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CONSERVATION & MANAGEMENT

REPRODUCTIVE AND ENDOCRINE RESPONSES TO DIFFERENT STRESSORS IN FEMALE SOFT-SHELLED TURTLES, *LISSEMYS PUNCTATA PUNCTATA*

Prajna Paramita Basu (Ray)[1] and B.R. Maiti[2]

[1] *Bangabasi College, Department of Zoology, Kolkata, India*
[2] *Histophysiology Laboratory, Department of Zoology, University of Calcutta, Kolkata, India*

Turtles encounter various kinds of stressors, but the effect of such stressors especially on endocrine regulation and ultimately on the reproductive behaviour of the organisms remains largely unknown. In the present study, the influence of the adrenal and thyroid glands on the gonads (ovary) was studied. Also the effects of different stressors (dehydration, salt loading etc.) on the adrenal and thyroid glands and on the reproductive physiology of female soft-shelled turtles, *Lissemys punctata punctate,* were investigated. In the current investigation, it is evident that stressor-induced hyperactive adrenal and hypoactive thyroid caused decreased gonadal activity, which will help us to understand breeding biology in order to preserve this endangered turtle species.

STATUS OF GREEN TURTLES IN KUWAIT

Salim Al-Mohanna and Preeta George

Kuwait University, Kuwait

The green turtles of Kuwait are discussed with reference to their nesting records, genetic studies and conservation efforts. The need to conserve this species is emphasized due to their endangered status and greatly reduced nesting grounds.

CONSERVATION NEEDS OF MARINE TURTLES IN GUJARAT

Deepak Apte and Dishant Parasharya

Bombay Natural History Society, Mumbai, India

Gujarat is blessed with a 1,650 km coastline encompassing a diversity of habitats varying from beautiful coral reefs in the Gulf of Kachchh to vast mudflats in the Gulf of Khambhat. There are also sandy beaches along the coastline of Kachchh and Saurashtra which are some of the most noteworthy sites of marine turtle nesting in the western coastline of India. Four species of marine turtle, olive ridleys, greens, leatherbacks and hawksbills, can be encountered in the waters along the sandy beaches of Gujarat. However only olive ridleys and greens nest along the shoreline of the state. Nesting activity is mostly concentrated in the areas of the Gulf of Kachchh and along the Saurashtra coast. However there is a lack of proper and long-term scientific monitoring in the state. This paper mainly deals with the current conservation status of the marine turtles in the area, with reference to the developmental activities taking place such as the Special Economic Zones on the coastline, establishments of Ultra Mega Power Plants and Port development. The paper also emphasizes the need for regular monitoring of the nesting sites and the current efforts undertaken by various stakeholders towards the conservation of marine turtles.

INCORPORATING RESEARCH, EDUCATION, AND ECOTOURISM INTO MEANINGFUL SEA TURTLE CONSERVATION IN GHANA

Ayaa K. Armah[1], Phil Allman[2], Dickson Agyeman[3], and Andrews Agyekumhene[1]

[1] University of Ghana, Legon, Ghana
[2] Florida Gulf Coast University, Fort Myers, Florida, USA
[3] Ghana Wildlife Division, Accra, Ghana

West Africa is home to five of the world's seven species of endangered sea turtles, but unfortunately very little is known about their population status, threats, and movements in the region. Due to political, financial, and logistical constraints in West Africa, there are few active sea turtle conservation programs that incorporate research, community education, and ecotourism. This contribution serves to illustrate our collaborative efforts to develop international collaboration that promotes sea turtle conservation by training international students, educating nearby communities, and developing ecotourism while simultaneously conducting rigorous research on the nesting populations that will serve to improve management of these critical species. Poaching has been minimal during the two years of the study and may be a result of the long-term presence of Ghana Wildlife Division (GWD) officers in the area, as well as the traditional story that many local residents observe. The Adali people of this region typically do not eat sea turtles due to a traditional story that describes a sea turtle rescuing a lost fisherman. This story, with the community education efforts by the GWD, has provided sea turtles with a relatively safe nesting area in Ghana. Unfortunately, feral dogs on the beach result in the destruction of nearly 90% of the nests deposited on the beach. To reduce this high rate of egg mortality, we suggest the government support a program to immediately remove the dogs off the beach or support the construction of a hatchery that will provide a safe location for the eggs.

ASSESSMENT OF SEAGRASS BEDS, ASSOCIATED FISHERY AND SOCIO ECONOMICS OF NORTHERN PALK BAY, SOUTHEAST COAST OF INDIA

V. Balaji[1] and S. Raveendran[2]

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[2] Khadir Mohideen College, Adirampattinam, Thanjavur District, Tamil Nadu, India

Seagrasses are the only flowering plants living immersed in seawater that are capable of reproducing entirely underwater. Seagrass beds serve as a breeding ground for a large number of species of marine fishes. This study aimed to collect detailed information on seasonal changes in biological variables of seagrass communities (including seagrass density, biomass, canopy height and percentage cover), spatial and seasonal variations in seagrass associated fish assemblages and its influence on socio-economics of seagrass dependent fishers. The study was carried out in the three coastal villages: Keezhathottam, Velivayal and Manora in Thanjavur District, Tamil Nadu, India. Three species of seagrasses *Halodule pinifolia*, *Cymodocea serrulata*, *Syringodium isoetifolium* were identified from the study area. Shoot density and biomass in the three seagrass species showed strong positive correlations with temperature and salinity. Seagrass productivity was high in summer, when salinity and temperature were at their peak level. Decomposition of seagrasses occurred largely during monsoon, when increased nutrient levels in the water column and enhanced plankton productivity might attract a great number of planktivorous fishes like *Sardinella longiceps* to the nearshore region. Assets, electricity facility, condition and structure of houses reflected the economic status and average income of the families. Most of the fishermen understand the role of seagrass beds for fishery productivity. Nearshore seagrass beds experience chronic disturbances caused by shore seining. Without proper alternative livelihood arrangements, fishery management and seagrass meadow conservation is not possible. Understanding the existing social-ecological systems is essential. In conclusion, it is quite clear that the northern Palk Bay seagrass meadows are healthy ecosystems with pristine nature that support the livelihood of fishers. At the same time, method and intensity of exploiting fishery resources from the seagrass beds by local fishers should be regulated through community awareness and long-term alternative livelihood arrangements.

MEAN SIZE OF LOGGERHEAD SEA TURTLES IN THE TYRRHENIAN SEA: CURVED CARAPACE LENGTH COLLECTED IN THE YEARS 2002–2007

Alessandra Bardi[1], Silvia Galli[1], Caterina Filannino[1], Luana Papetti[2], Rosario Fico[3], Riccardo Sirna[2], and Alessandro Ligas[2]

[1] University of Pisa, Italy
[2] Acquario Comunale di Grosseto, Grosseto, Italy
[3] Zooprophylactic Institute of Latium and Tuscany, Grosseto, Italy

In 1996, loggerhead sea turtles were included by the Marine Turtle Specialist group in the IUCN Red List of Threatened Species as endangered. Among the reasons for the decline of this species, there is certainly high mortality due to accidental fishing: in Italy it is estimated that every year more than 20,000 turtles are caught in fishing nets, with a mortality rate of more than 30%. In the last few years the number of rescue and rehabilitation centres funded by major conservation organizations (i.e. WWF, Legambiente) has increased. In Italy there are more than 20 rescue and recovery centres and the number is still increasing. The "Acquario Comunale di Grosseto" has monitored the Tyrrhenian Sea in search of endangered sea turtles since 1993. A total of 127 specimens of *Caretta caretta* have been recovered: 37 of these were found dead, while the remaining 85 were successfully rescued and then released. During the residence in the center we recorded the cause of the injury and the general health of the animals and some parameters concerning length, width, and weight. Sea turtle population dynamics is still poorly known, and this makes it difficult to understand how the populations of these threatened species respond to human impacts, and to plan suitable conservation strategies. In the present study our purpose was to make an estimation of the age (detected from the size) of loggerheads inhabiting the Tyrrhenian Sea, considering the fact that only a few occasional nests have been reported for the Tyrrhenian coast (and therefore that adult individuals are rare in this area). However this highly productive sea is considered an important feeding site for juvenile and sub-adult individuals. The average nesting female sizes observed at the most important Mediterranean nesting sites is 66.5–84.7 cm CCL (curved carapace length), which can be considered an approximation of the size at maturity. We considered the mean size of the turtles recovered in the period between 2002 and 2007. In these years, 67 specimens were recovered and 55 individuals were subsequently released. The CCL of the collected specimens ranged from 27.5 to 78 cm. The maximum average CCL (46.86 cm, n = 26) was recorded in turtles caught in 2007, followed by 2003 where the value was 42.98 cm (n = 24). Considering the approximation of the size at maturity, the specimens recovered can be mostly considered as juveniles and sub-adults (CCL < 66.5 cm). From 2002 only four individuals were bigger than the size at maturity, and could be considered as adults (67.0, 78.0, 71.5, 68.0 cm CCL, respectively). Further analyses regarding population dynamics of sea turtles in the Tyrrhenian Sea are in progress: we think that this type of analysis is a useful tool for wildlife conservation management and improvement of protection measures.

*CONSERVING TURTLES IN THE TORRES STRAIT – COMMUNITY-BASED MANAGEMENT, PLANNING AND IMPLEMENTATION

Kenny Bedford[1], John Wigness[1], and Frank Loban[2]

[1] Torres Strait Island Regional Council, Australia
[2] Torres Strait Regional Authority, Australia

Indigenous communities located in the Torres Strait, Australia have been involved in the Dugong and Turtle Project since 2006. A primary focus of the project has been the development of community-based management plans. Eight communities have developed traditional owner endorsed plans whilst the remaining seven have begun developing draft plans. The project has involved a collaborative approach from Torres Strait Islanders (TSI) and relevant stakeholders including the Australian Government and Research Institutions. Traditional owner involvement in turtle and dugong research and monitoring activities has allowed the exchange of traditional knowledge with contemporary turtle and dugong conservation issues and research methodologies. Through a collaborative partnership with James Cook University, training has also been provided to traditional owners to develop their technical skills and increase community awareness of turtle management and conservation issues. As a part of the implementation of the community based plans, the Torres Strait Regional Authority has successfully secured $11.3

million for the Australian Governments Caring for Our Country Program to establish and implement a Ranger Program in the Torres Strait. The Torres Strait Indigenous Ranger Program is being delivered in collaboration with the Torres Strait Island Regional Council and traditional owners. Rangers are currently undertaking the following activities within their communities: 1) catch-monitoring of both dugongs and turtles 2) monitoring of foraging dugongs and turtles 3) conducting tagging of foraging and nesting turtles 4) conducting surveys of nesting for hawksbill, green and flatback turtles 5) promoting the community based dugong and turtle management plans in their respective communities. Torres Strait Islander representatives presented on work activities and outcomes achieved through the Ranger Program thus far, in particular, the challenges faced with the implementation of these community based plans. The TSRA Portfolio Member for Fisheries also presented on how the planning process has supported and reinforced indigenous hunting rights.

SEA TURTLE AND THEIR HABITAT PROTECTION AT DEVI ROOKERY OF ORISSA, INDIA

Sovakar Behera

Green Life Rural Association, Orissa, India

Conservation oriented work was undertaken along the Devi sea turtle rookery of Orissa in India from February to May 2009. The project aimed to protect olive ridley sea turtles and their nests, eggs and nesting beach during the breeding season through multiple activities such as beach cleaning, in-situ nest protection and community awareness programmes. The entire 37 km nesting beach at Devi rookery had all garbage removed. All nests on the beach were protected round the clock. Participation for sea turtle conservation was also encouraged through education and awareness programmes at the communities of the adjoining villages of Devi sea turtle rookery. Based on this, specific recommendations have been made for long term conservation and monitoring of olive ridley sea turtles at Devi rookery of Orissa coast in India. The poster depicts the main objectives of the conservation interventions, the methods by which effective community participation was achieved and the recommendations that evolved from our findings and observations. These recommendations will not only inform future programmes of our organisation, but could also benefit others working with communities and turtles.

*FOLLOW-UP AND RELEASE OF MARINE TURTLES INCIDENTALLY CAUGHT IN TRADITIONAL FISHING NETS: A COMMUNITY BASED PROGRAM IN THE REPUBLIC OF CONGO

Nathalie Breheret[1], Manuel Adell[1], Gaëlle Bal[1], Karine N'Damite[1], Philippe Fasquel[1], and Alexandre Girard[2]

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Renatura is an NGO acting since 2001 for sea turtle protection and study in the Republic of Congo (Congo-Brazzaville). At first, the NGO developed a nesting survey program in Congo. From the beginning the NGO has founded its actions on local staff. Thanks to this work involving the local community, fishermen soon raised the issue of incidental captures of sea turtles in gillnets. Meetings were then organized with coastal inhabitants and local authorities to collegially find solutions to reduce the impact of this threat on sea turtles. An agreement was reached according to which fishermen make the commitment to alert the NGO by phone in the case of a sea turtle incidental capture. The Renatura staff then go on site to collect biometrical data, tag the animal, and assist fishermen in the release of the turtle alive. On the other hand, the NGO makes the commitment to deliver the material necessary to fix the net. There is no money in the deal, just net wire, bobbins and net pieces, the amount of which is negotiated by the Renatura staff. The "releasing program" has further developed and it is now proposed on the entire Congo coastline. This approach presents many advantages. First of all, it allows reduction of the impact of the threat represented by incidental capture in gillnets. Each year, more than 1500 incidental captures led to a release. The number of turtles found on the market has lowered strongly. Indeed, the fishermen used to sell the turtle meat at the local market to compensate for the cost of fixing the damaged fishing net. The material compensation furnished by Renatura has broken its use. Furthermore the data collected and the tagging of captured turtles give a precious insight on the sea turtle populations all through the year, complementary to the data collected on adult female turtles nesting on the beach. Since it has been launched, the releasing program met with great success and is now a part of

the fishermen's habits. More than 6,000 capture events have led to a release. As the project is now well-established in Congo, Renatura has begun a community based touristic activity linked with the releasing program. It takes place, for its development phase, in the village where the number of releases is the highest: La Pointe Indienne, at one end of the Loango bay. Participation in a "liberation" session is proposed to tourists. The fee they pay is split into two parts. One part is used to self-finance the releasing activities. The other part is put in a community fund intended for village development projects. This new aspect of the program values the conservation efforts conceded by the community working with Renatura. This way (living) sea turtles rose to the rank of community resource. It brings a new view on endangered fauna species among villagers and fishermen.

*16 YEARS OF RUNNING A MARINE TURTLE CONSERVATION PROJECT: HOW DO WE MEASURE SUCCESS?

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The author has conducted a marine turtle conservation project in the Chagar Hutang Turtle Sanctuary in Redang Island since 1993, making 2008 the 16th year of operation. From its beginnings as a grass-roots conservation project focused on in-situ protection of nests deposited on the beach, it has developed into a comprehensive programme incorporating full nest protection, audience-specific turtle awareness camps, involvement of dedicated volunteers, turtle and nest adoption schemes and conservation-related research, some of which is carried out by undergraduate and post-graduate students. Obviously, the ultimate measure of success of the programme would be recovery of the nesting population. However, the long maturation time of marine turtles (20–50 years) requires that we explore alternative measures or indicators of success. These may include proportion of nests protected, hatch rates, frequency of educational turtle camps, volunteer participation rates, numbers of nests and turtles adopted (fund-raising), research output, student research activity and institutional support. Support from local communities, resort operators on the island, corporate bodies and the public at large can also be gauged. Milestones reached in advocacy may also provide measures of success. These alternative measures of success can be translated into conservation gains on the ground in terms of increasing proportion of nests protected, increased public awareness through the intensification of educational activities and development of interpretive exhibits in the sanctuary for visitors, student training and subsequent recruitment to ensure continuity of the long-term conservation project and development of a viable and long-term fund-raising strategy through public outreach programs (volunteer program and nest and turtle adoption schemes) to enable self-sufficiency in the conservation project. Conversion of the nesting area into a turtle sanctuary by the State Government through advocacy constitutes an important measure of success as well. Furthermore, the interim analysis of nesting trends in the sanctuary appears promising.

HATCHING SUCCESS IN IN-SITU AND RELOCATED GREEN TURTLE (*CHELONIA MYDAS*) NESTS INCUBATED AT CHAGAR HUTANG, REDANG ISLAND, TERENGGANU

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A total of 55 nests were excavated and analyzed to determine the hatching success of green turtle (*Chelonia mydas*) nests at Chagar Hutang, Redang Island. Among those, 35 nests were in-situ nests, while 20 nests were relocated nests. The latter were relocated when they were attacked by ants during the incubation period. The average hatching success of in-situ nests was 73% (n=35, ±26.33) whereas the average hatching success in relocated nests was 72% (n=20, ±24.85) both ranging from 0% to 100% in values. Among the eggs that had been predated upon in in-situ nests, the main predator was ants (70%) followed by ghost crabs (23%), plant roots (5%) and maggots (1%). In relocated nests the trend was different: ants (50.8%) were still the main predator but maggots had the second highest percentage (33%) followed by ghost crabs (12%) and plant roots (3%). There was no significant relationship between hatching success and nest depth or vegetation distance. Microfungi were often found on the exterior of unhatched eggs in sea turtle nests in Chagar Hutang. Fortuitous egg mortality provided a nutrient source for common soil mycobiota (*Fusarium* sp. and *Aspergillus* sp.) and served as a focus for the progressive spread of fungal hyphae to adjacent viable eggs. In extreme cases the entire egg mass was rotten and resulted in nil hatching

success. Maggot culture showed those maggots are Scuttle flies, *Megaseleria scalaris* (Order Diptera, Family Phoridae).

*MINIMIZING FIELD WORK AND OPTIMIZING OUTPUTS: MONITORING STRATEGIES FACE THE REAL WORLD WITH AN EXAMPLE CASE IN GUADELOUPE (CARIBBEAN)

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Field monitoring permits estimation of the number of nests deposited annually at a given place. However, when many small beaches are present at a particular site, the monitoring strategy can be very difficult. The situation in Guadeloupe is particularly difficult with more than 100 beaches available for marine turtles. We develop a strategy to monitor such a situation and we test the feasibility of the strategy in Guadeloupe. We were able to estimate the nesting activity in half of the beaches with very few volunteers. Finally, guidelines are proposed to monitor nesting activity at nesting beaches that can be used efficiently in nearly all situations.

SHARING COMMUNITY BASED CONSERVATION EXPERIENCE – THE CHALLENGES IN SEA TURTLE CONSERVATION – SOUTH EAST COAST, INDIA

Supraja Dharini

Chairperson of Tree Foundation, Vettuvankeni Chennai, India

This paper expounds the successes, struggles and challenges of achieving conservation goals directed at protecting sea turtles and their marine habitats involving communities living along the coast. Rampant destruction of ecosystems by coastal communities – caused mainly by illiteracy and poverty – is a major problem for marine conservation in the Kancheepuram coast in Tamil Nadu, India. Coastal communities depend on marine natural resources for survival. As a result, important habitats and fauna such as the reefs, sea grass beds, mangroves, estuaries and marine turtles are being destroyed and there is therefore an urgent need for protection. The olive ridley (*Lepidochelys olivacea*) nests on the Kancheepuram Coast and juvenile hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) forage in the ocean of the study area. There is an urgent need to protect the ridley nesting sites along the coast and adult olive ridley turtles en-route to the mass nesting beaches of Orissa. It is also imperative to reduce fishery related mortality to juvenile hawksbill and green turtles foraging in the ocean habitat before the turtle populations collapse. TREE Foundation was founded in 2002 with the aim of protecting marine turtle populations, understanding the interrelatedness between coastal communities and the marine resources upon which the former survive. To focus on initiatives that combine conserving species and habitat with empowering local people is the only solution – incorporating the human element from a variety of perspectives including education programs, capacity building, economic development/poverty alleviation, human and animal health programs and networking with various government departments/agencies. For the conservation of marine and coastal resources and alleviation of poverty, a multi-pronged approach is underway with six main components, such as, 1) artisanal fisher participatory governance for marine conservation, 2) alternative income generating projects, 3) partnership building/networking, 4) health and hygiene, 5) bio-gas. The Foundation has implemented community health programs. The cornerstone of TREE Foundation's community wellness program is 'Child's Health is Nation's Wealth' which focuses on free fruit, herbal kitchen garden and cereal grass projects. Upgraded primary school education and English language and computer classes are examples of the programs executed. Livelihood development programs have been initiated in collaboration with the National Fisheries Development Board. TREE Foundation will provide training in alternative livelihood skills for the self-help group fisher youth and women members. Multiple partnerships are essential for the project's success.

CORREDOR AZUL: MARINE PROTECTED AREAS AND SEA TURTLES IN THE SW ATLANTIC

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Sea turtles are highly migratory animals that use a wide variety of habitats during their life span. Therefore, research and conservation efforts must be coordinated and conducted cooperatively among nations involved, going beyond geographic and politic boundaries. For this reason, during the V Meeting on Sea Turtle Research and Conservation of the Southwest Atlantic (October 1 2009, Mar del Plata, Argentina), the first workshop on Green Turtles and Protected Areas was conducted. Its main goal was to promote the exchange of knowledge and experiences between researchers and conservationists working with green turtles in Brazil, Uruguay and Argentina in order to assess connections between nesting and feeding populations, recognize common threats and also identify gaps in sea turtle knowledge and unprotected critical habitats along the species distribution. According to several studies employing genetics, mark-recapture and remote sensing tools, populations of juvenile green turtles are shared by the three countries. These populations are mainly affected by incidental capture, especially in artisanal fisheries, and marine debris ingestion due to anthropogenic pollution. In this region, coastal and marine protected areas cover an important proportion of the species distribution, especially in Brazil. However, some gaps have been identified. In some protected areas in Brazil, no sea turtle information is available. Moreover, critical feeding habitats like the Río de la Plata estuary, shared by Argentina and Uruguay, are completely unprotected. We encourage similar experiences in other regions, enhancing communication and coordination between researches from different nations in pursuit of sea turtle conservation.

SEA LEVEL RISE AND LEATHERBACK CONSERVATION: IMPLICATIONS AT LAS BAULAS NATIONAL PARK, COSTA RICA

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Scenarios are needed to better plan for coastal development and protected areas, in a way such that both marine turtles and local communities benefit. Playa Grande, the most important nesting site in the Eastern Pacific for the critically endangered leatherback turtle, is located in Las Baulas National Park, Costa Rica. It is realistic to expect a 1 m sea-level rise by the end of the century due to climate change. This would imply a 50 m landwards retreat of the beach. Additionally, the high-resolution digital elevation model reveals that for the most part the inundation of the Playa Grande area will occur from behind. As sea level rises, the water will advance through the mouth of the Tamarindo estuary into the surrounding wetlands, inundating part of the land bordering the current mangroves. The future of Playa Grande depends on its ability to retreat as sea level rises and at the same time maintain adequate ecological conditions for the nesting of leatherbacks. This implies that existing and future infrastructure does not hinder the retreat of the beach and that the buffer zone of the national park warrants effective environmental mitigation measures in light of the future locations of the beach and the retreat of the mangroves. A recent law proposal to rectify the boundaries of the park would reduce its width to a fringe of 50 m and implies that the park would be underwater by the end of the century. The beach would be located inside the proposed wildlife refuge of shared management with property owners, and turtles and their nests would compete for space with houses and other infrastructure. Once the beach retreats towards the infrastructure, the wave activity against roads and buildings will cause erosion and consequently loss of nesting area. In relation to rising sea levels, the proposal to rectify the boundaries of the national park is shortsighted and not precautionary. It would compromise its ecological role as a leatherback nesting area both in the mid-term and in the long-term, and therefore undermine the very reason for the

creation of this particular park. Implementation of adaptation measures to counter the impacts of climate change on turtle nesting beaches is an international commitment under the Inter-American Convention for Marine Turtle Protection and Conservation, to which Costa Rica is a signatory party. With the implementation of such measures, Costa Rica has the opportunity to maintain its regional leadership in the conservation of marine turtles and its status as a world-class reference in biodiversity conservation.

*MARINE TURTLE ECOLOGY AND HERACLITUS' RIVER

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Marine turtles are remarkable for their complex life cycles, with critical life stages on the high beach, intertidal beach, coastal waters, and high seas, as well as the recurrent oceanic migrations. With a decade or more just to reach sexual maturity, their ecological interrelations can only be understood after systematic studies that encompass not just enormous spatial expanses, but also vast temporal periods. Because of the complex life cycle, these reptiles obviously occur in diverse ecosystems, and enjoy very different roles in each of them. Given the dynamic nature of each of these environments, research must not only take into account environmental cycles (e.g., diurnal, tidal, lunar, seasonal, solar, ENSO, etc.), but also trends (e.g., ocean acidification, global warming, sea level rise, beach erosion/deposition, coral reef bleaching, marine contamination, coastal development, turtle population declines, etc.) and stochastic events (e.g., cyclones, tsunamis, sea grass pasture decimation and unexpected declines in other food items, peaks in predator or competitor populations, cascade effects in trophic webs, etc.). A primary reason that long-term studies are essential is to provide adequate time to sample the wide range of this environmental variation, and thereby arrive at robust generalisations about the ecological questions under study. In general, ecology, and consequently biological conservation, pays special attention to spatial issues, but temporal considerations are underestimated and inadequate: marine turtle research must not fall into this gyre. It is indefensible, and naive, to assume that a vast array of environmental parameters – abiotic and biotic, nonhuman and human – remains constant and that a short term sample will be representative of complex, dynamic phenomena. In sum: Heraclitus must guide any attempts to understand ecological roles of these complex marine reptiles.

IMPACTS OF CLIMATE CHANGE ON SEA TURTLES NESTING GROUNDS: USING EXPERT'S OPINION TO INFORM MANAGEMENT

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Managing species and ecosystems in the face of climate change will require understanding the relative impacts of different climate change threats. For example, the terrestrial life stage of sea turtles can be threatened by sea level rise, changes to cyclonic activity, and increased sand temperatures. However, no study has systematically investigated the relative impact of each of these factors, making it challenging for managers to prioritize their decisions and focus their management. We use a case study of the world's largest population of green sea turtles to explore how scientific and management experts quantify the relative impact of these key threats. Experts were also asked to indicate how certain they were about their answers so that we could identify where knowledge gaps exist. We also investigated whether there were differences in how managers and scientists ranked both the threats and consequences and also summarize key management actions highlighted by the experts. Twenty-two scientists and managers completed our survey. Both scientists and managers agreed that increased sand temperature was the greatest likely threat, followed by sea level rise, then cyclonic changes. However, scientists placed less weight on increased sand temperature and more weight on sea level rise than managers. Experts were in wide agreement about many of the likely consequences of these threats, although managers viewed the possibility of more intense and more frequent cyclones as more severe than scientists. Both scientists and managers perceived high levels of uncertainty about many of the potential consequences of climate change to sea turtles. Thus, further research on this topic is warranted, especially with regards to the adaptive capacity of turtles. A variety of management options were suggested by the turtle expert panel to mitigate the impact of climate to the reproductive output of sea turtles. Some

of the measures, especially the active ones (such as manipulating thermal gradient on beaches), have previously been identified by other studies. However, more than 60% of the respondents suggested indirect management measures, such as environmental education with locals and reduction of emissions, to increase sea turtles resilience. The experts also noted uncertainty about the feasibility, effectiveness, risks and benefits of most of the active management measures and suggested risk-based studies to investigate which management measures are feasible and cost-effective. The need for regional-scale protocols for implementing active management strategies was also expressed.

AFTER SEVENTEEN YEARS OF CONSISTENT MONITORING: A SPATIAL ANALYSIS OF SEA TURTLE NESTING TRENDS IN NORTHERN CYPRUS

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North Cyprus holds significant regional nesting populations of both loggerhead (*Caretta caretta*) and green turtles (*Chelonia mydas*). We present data from our monitoring and conservation programmme which has been running annually for 17 years (1993–2009). We analysed data from our main index beach at Alagadi and other key nesting sites from around the coastline of Cyprus. A significant improvement in the proportion of clutches that hatched successfully was achieved by a substantial reduction in the numbers of clutches predated or inundated. While increases in clutches laid are recorded at some sites others appear to be in decline. This may reflect true population trends or a spatial shift in nesting between sites, which is of key interest to those undertaking population monitoring using index beaches. This highlights the need for long term, consistent and widespread monitoring in order for robust estimates of nesting population trends to be made.

MARINE TURTLES IN CONTINENTAL ECUADOR: NEW INSIGHTS INTO AN OLD POPULATION

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It has been many years since Green documented the occurrence of four species of sea turtle along Ecuador's continental coast in 1981. These were *E. imbricata*, *C. mydas*, *D. coriacea* and *L. olivacea*. Sea turtle activity along the country's coast has since then only been characterized by track counts and anecdotal reports. In 2007 Equilibrio Azul began the first systematic sea turtle research along Ecuador's continental coast, confirming nesting of the four previously mentioned species and the existence of foraging sites for all except *D. coriacea*. In 2008, interview surveys were conducted along Ecuador's entire coast in order to identify sea turtle nesting and in-water aggregation areas. Based on the results of these surveys, three sites were selected for further studies, including nesting beach and in-water monitoring. Several beaches within Machalilla National Park (MNP) were identified as the main nesting grounds for *E. imbricata* and *C. mydas* along the country's coast with 31 and 22 nests registered for these species, respectively (2008–2009). It is also the only nesting ground identified to date for hawksbill turtles along the Pacific Coast of South America. La Plata Island is located within the marine protected area of MNP and has been found to be the most important nesting and foraging area for green turtles along the mainland, with 42 nests (2007–2009) and nearly 200 individual animals identified. Located in Northern Ecuador, Portete is the most important nesting beach for *L. olivacea* identified so far in the country, with 11 nests having been observed in 2008. Despite the lack of historical data, the information obtained by these studies demonstrates Ecuador's importance for sea turtle nesting and foraging in the Eastern Pacific. These findings also highlight the urgent need to increase research and conservation, as well as expand studies to document and manage sea turtle fisheries bycatch and habitat destruction, which have been identified as the most important threats to sea turtles in the country. Here we present these and other results of sea turtle monitoring and research along Ecuador continental coast.

MORPHOMETRIC ANALYSIS OF THE EXTERNAL BODY ANATOMY OF THE AFRICAN SIDENECK TURTLE (*PELUSIOS SINUATUS*)

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Morphometric studies were carried out on a total of 14 external body parameters of the African sideneck turtle (*Pelusios sinuatus*) with the aim of obtaining vital data which would be useful in the gross and regional anatomy of the animal. Twelve adult male turtles were used for the study; they were picked up at various times at different river banks and streams within Ibadan, Nigeria. All body measurements were obtained using a vernier caliper and a metric tape while body weight was obtained with the aid of a Microvar® weighing balance. The average weight of the turtles was 1.25 ± 0.35 kg with an average body circumference of 41.5 ± 4.36 cm. The straight and curved carapace lengths were 21.0 ± 2.30 cm and 25.0 ± 2.45cm respectively with a significant difference ($p<0.05$) while the straight and curved carapace widths were 17.3 ± 3.16 cm and 23.6 ± 3.21 cm respectively being significantly different ($p<0.05$). The maximum head width, head length, orbital diameter, neck length and maximum body depth were 3.5 ± 0.23 cm, 4.2 ± 0.45 cm, 0.6 ± 0.12 cm, 3.7 ± 0.32 cm and 8.0 ± 2.34 cm respectively. The straight and curved plastron lengths were 19.4 ± 3.26 and 20.3 cm ± 3.12 cm respectively while the average tail length was 4.0 ± 0.38 cm. There was a strong positive correlation ($r= 0.84$) between the weight of the turtles and the body circumference while the weight of the animals correlated weakly ($r= 0.23$) with the lengths of both the carapace and plastron. The information made available by this study serves as a baseline data useful in the gross and regional anatomy of the animal and is also a vital tool for the comparative anatomy of turtles.

*NEW FACTS ON SEA TURTLES IN THE REPUBLIC OF CONGO ACCORDING TO THE ANALYSIS OF DATA COLLECTED ON SEA TURTLE INCIDENTAL CAPTURES

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Renatura is an NGO which has been working on sea turtle conservation in the Republic of Congo (Congo-Brazzaville) since 2001. Renatura acts in different ways, including monitoring of the nesting females, surveying and releasing turtles incidentally captured in traditional fishing nets and running educational campaigns in schools, and awareness sessions in market places, town halls, and coastal villages. Two turtle species regularly nest in Congo: the leatherback turtle (*Dermochelys coriacea*) and the olive ridley turtle (*Lepidochelys olivacea*). Two other species are present along the coast: green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*). Loggerhead turtles (*Caretta caretta*) seem to have sporadic occurrences. A releasing program was launched by Renatura in 2005. Since then, more than 6,000 sea turtle capture events have been recorded. For each capture event, biometric data are collected, and the turtle is tagged if released. Other observations such as the presence of tumors, other lesions and wounds and scute abnormalities are also noted down. These data were used to evaluate sea turtle population size for each species. Tagging and rereading data allows capture-recapture modeling. It shows that more than 2,000 juvenile and sub-adult greens are frequenting the Congo's waters. Temporal variations in the number of capture events were also studied. This parameter has been supposed to be correlated to the temporal variations of each population size. Different variation patterns were tested: constant, linear and annual. For leatherbacks, the variation of the capture numbers is in phase with the leatherback nesting curve. On the other hand, olive ridleys (LO) capture variations do not follow the nesting curve. The LO capture variation pattern is linear, meaning that LO are present in Congolese water throughout the year and during the non-nesting period. For green turtles, the variation analysis brings forward a difference between the behavior of adults and juveniles. Variation of the juvenile captures fit with an annual period curve. On the opposite, variations of capture fit with a constant model for adult green turtles. It suggests that juvenile greens have seasonal moving patterns: they are numerous in the Congolese waters from May to August and seem to move away from October to March. It would be interesting to determine the place they are moving to, for example by putting tracking devices on some juvenile greens in August. Genetic studies also bring some useful

complementary information. A genetic link between green turtle of the Congo and those of the Bioko Island (Equatorial Guinea) has been shown. There may be seasonal movements between these two sites. The data collected on captures also indicate a high prevalence of Fibropapillomas (FP) in CM. 40% of the individuals with CCL size > 60 cm have FP. For smaller individuals, the prevalence is lower: around 20%. The prevalence makes a sudden shift from 20% to 40% at the 60 cm CCL threshold. This suggests that clinical signs are linked to a particular stage of life. The green turtles could also have been infected in a distant area they could frequent during their development cycle.

PRAKRUTI NATURE CLUB PROFILE

Dinesh Goswami and Jignesh Gohil

Prakruti Nature Club, Kodinar, Gujarat, India

Our presentation will consist of a profile for our NGO, the Prakruti Nature Club. We are based in Kodinar, Dist-Junagadh, Gujarat and specialize in working on sea turtles, whale sharks, migratory birds and other wildlife. We also work on environmental education, awareness and conservation programmes on the coast of the Arabian Sea at Gujarat State, India. Our efforts for sea turtle conservation include nest counting and disposing of dead turtles. Camps for wildlife conservation are also organized by our club to educate people and create awareness to conserve wildlife, especially sea turtles in this region.

HATCHERY IN LE MERIDIEN BORA BORA/FRENCH POLYNESIA: EGG INCUBATION FROM DEAD NESTERS CONFISCATED FROM POACHERS

Sebastien Goutenegre

Chelonia Polynesia, Bora Bora, French Polynesia

Every year, between December and January, in cooperation with customs and French police, our team welcomes hundreds of eggs confiscated from poachers and most of the time taken from a dead nester's belly (*Chelonia mydas*). This point is very important to underline because these eggs haven't been laid but instead were taken away from a dead body. This means that we have very few studies and results available on the incubation of this kind of egg in French Polynesia. The peak of nesting and poaching season in French Polynesia is in December. We have created a unique hatchery on a special islet on Bora Bora, in natural conditions to preserve sex ratio determination, which enables hundreds of eggs from green sea turtles to incubate. This kind of conservation action helps in educating tourists and local school kids about poaching consequences. We started this action a few years ago, with success depending on several factors (temperature, egg quality, sand quality, incubation place, human manipulations etc.). We recreate a nest in the sand in a proper place, mostly under miki miki trees that we could find on natural nesting beaches in French Polynesia, and put eggs in an 80 cm (2.5 ft.) deep hole. If possible, we try to collect the whole oviduct full of eggs or if not just eggs. These eggs incubate between 60 to 70 days depending on outside temperature and weather. Now, at least 50% of eggs we incubate produce hatchlings. We raise these juveniles for three years in our natural inner lagoon before we release them to the wild. Of those 50% that hatch, we raise at least 60% to reach three years old. This unique action helps to preserve these eggs and give them a chance to incubate. This conservation action helps to preserve the fragile French Polynesian sea turtle population in the face of poaching activities. In the future, we would like to develop ecotourism activities like turtle nest watching, counting on those turtles that hatch today to repopulate their natural nesting sites on Bora Bora in the next 30 years. This could be a way to involve local populations, especially the next generation, in sea turtle conservation, through creating jobs as rangers or naturalists. We hope that green sea turtles survive in French Polynesia for the next 30 years for our children's children heritage.

MASSIVE LOGGERHEAD NEST PREDATION BY GHOST CRABS IN BOAVISTA ISLAND (CAPE VERDE): IMPLICATIONS OF THE ABSENCE OF LARGE PREDATORS

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The impact of nest predators on sea turtle hatching success is highly variable depending on predator abundance and also on interactions among different predators. Food web connectivity usually makes it difficult to understand predator-prey interactions and develop efficient conservation strategies. In the Cape Verde archipelago there is an important nesting area for loggerheads where ghost crabs are the only described nest predator. We have studied the impact of ghost crabs on loggerhead nests on this threatened population as well as the efficiency of several management practices to reduce this impact. One hundred nests were incubated on the beach under 5 different treatments: 20 were incubated in their natural locations but fully protected from egg predation, 20 were partially protected by placing a 1 m^2 plastic mesh over the nests, 20 were left unprotected in the same location, 20 were relocated on the beach and left unprotected and 20 were relocated to a hatchery without crabs. All eggs were counted at the beginning of the study and information on predator attacks, incubation duration, the number of predated eggs and hatching success were recorded for all nests. Ghost crabs (*Ocypodes cursor*) were the only nest predators. Seventy-nine of 80 nests located outside the hatchery were attacked by crabs and this happened mainly at the end of the incubation. Only 5 of 80 nests were attacked during the first 15 days of incubation and the first attack occurred on average at day 40 of incubation. In all unprotected nests the crabs robbed an average of 48 eggs per nest (mean clutch size = 87). For that reason, it is necessary to record clutch size at the oviposition in order to accurately estimate that parameter and hatching success. Embryo mortality averaged 67.5% in unprotected and non-relocated nests and 17.8% in fully protected and non-relocated nests. Ghost crabs directly predated or caused the secondary death of 50% of eggs. Relocation on the beach to selected areas decreased mortality less than 10%. Relocation to a hatchery significantly reduced mortality to an average of 35.4%, suggesting the existence of factors associated with relocation that affect embryonic survival. The protection with a 1 m^2 flat mesh over the nest reduced mean mortality from 67.5% to 40%, not fully protecting eggs from ghost crab predation and having a similar effect on hatching success to relocation to the hatchery. Nest predation by crabs in Cape Verde, in the absence of other larger predators, is very high. The loggerhead turtle population from Cape Verde is facing extinction because of severe environmental impacts and illegal activities. Improving hatching success by reducing nest predation can be very important to slow down the collapse of the population. The results of this study recommend nest relocation to a hatchery on beaches of high nesting activity and full nest protection against crabs on islands or beaches with very few nests.

*PRIORITIES FOR SEA TURTLE CONSERVATION RESEARCH

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We invited a sample group of 40 active sea turtle researchers from 13 nations to outline the essential research questions for sea turtle conservation. We asked each to submit up to 10 research questions that were considered priorities for informing sea turtle conservation. Of the 40 invitees, 35 individuals submitted 347 questions. These were collated by four of us into 14 themes or subthemes, and subsequently condensed into 20 principal metaquestions arranged in five categories, as follows: 1. Reproductive Biology: 1.1 What are the biotic and abiotic factors that underpin nest-site selection and behaviour of nesting turtles? 1.2 What are the primary sex ratios being produced and how do these vary among or within populations and species? 1.3 What factors are important for sustainable hatchling production? 2. Biogeography: 2.1 What are the population boundaries and connections that

exist among rookeries and foraging grounds? 2.2 What parameters influence the biogeography of oceanic sea turtles? 2.3 Where are key foraging habitats? 3. Population Ecology: 3.1 Can we develop methods to accurately age, determine age at maturity, and define age-based demography? 3.2 How to get reliable estimates of demographic parameters? 3.3 Developing an understanding of sea turtle metapopulation dynamics and conservation biogeography 3.4 What are the past and present roles of sea turtles in the ecosystem? 3.5 What constitutes a healthy turtle? 4. Threats: 4.1 What will be the impacts from climate change on sea turtles and how can they be mitigated? 4.2 What are the major sources of fisheries bycatch and how can they be mitigated in a way that is ecologically, economically and socially sound? 4.3 How can we evaluate the effects of anthropogenic factors on sea turtle habitats? 4.4 What are the impacts of pollution on sea turtles and their habitats? 4.5 What are the etiology and epidemiology of fibropapillomatosis (FP), and how can it be managed or prevented? 5. Conservation Strategies: 5.1 How can we effectively determine the status of sea turtle populations? 5.2 What are the most effective cultural, legal and socio-economic frameworks for sea turtle conservation? 5.3 Which conservation strategies are working (have worked)? Which have failed? 5.4 Under what conditions (ecological, environmental, social and political) can consumptive use of sea turtles be sustained? There are some general patterns to the metaquestions. Many of the questions highlight the lack of basic life history information of sea turtles, despite more than several decades research. There was a link between life history data and modelling, although there was also recognition that new models are also needed. Many of the question themes (e.g. bycatch evaluation and mitigation) are consistent with previous exercises to rank priority conservation actions, such as the MTSG Global Strategy for Sea Turtles. Interestingly, questions relating to the assessment of climate change impacts to sea turtles were the most commonly submitted theme. Most of the questions were focused on biophysical science, likely due to a bias in participants who specialize in biology. It would be interesting to conduct a similar exercise with non-biophysical scientists, to compare results.

20 YEARS OF WILDLIFE CONSERVATION BY THE ENDANGERED WILDLIFE TRUST IN COSTA RICA AND PANAMA

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The British registered charity the 'Endangered Wildlife Trust' was established in 1989 when 800 hectares of beachfront property on the Caribbean coast of Costa Rica were purchased to form the 'Reserva Pacuare.' Vast areas of the primary tropical forest in the surrounding area and within the reserve had been cleared for farming purposes, leaving many species of flora and fauna under threat. The initial aim of the EWT was to allow natural forest rejuvenation and to provide habitat and species protection. After the purchase of the land, it was discovered that large numbers of leatherback sea turtles (*Dermochelys coriacea*) were using the Reserva Pacuare as a nesting site. At this time it was estimated that approximately 95% of all nests in the area were being taken illegally by local poachers. The hunting of green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*) for meat and carapace was also widespread within this nesting zone. The EWT quickly saw the urgent need to protect the sea turtle populations and by 1994, a comprehensive monitoring and protection program was in place to cover the 6 km of nesting beach, to reduce excessive poaching levels and to study the nesting females. An increased level of protection was attained for sea turtles when four other smaller community-based projects were later established to address the alarming turtle slaughter on bordering Panamanian beaches. With a dedicated team of staff, volunteers, student groups and supporters, 20 years of wildlife conservation through habitat protection, environmental education, scientific research and working with local communities has proven to be highly successful. The Reserva Pacuare is now not only one of the most important and best protected leatherback nesting beaches in Costa Rica, but also provides a refuge for hundreds of threatened species of flora and fauna. In conjunction with the protection provided by the Reserva Pacuare, the Panamanian projects have ultimately increased the chances of survival for the nesting sea turtle populations.

SEA TURTLE CONSERVATION AND RESEARCH EFFORT IN BANGLADESH BY MARINELIFE ALLIANCE

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Bangladesh is situated at the north of the Bay of Bengal and comprises 710 km of coastline of which only several hundred are sandy and suitable for sea turtle nesting. Five sea turtle species frequent our marine territory, all of which also occur in other South Asian countries. In Bangladesh sea turtle conservation started in 1996 at St. Martin Island. This presentation depicts sea turtle conservation and research efforts in coastal and marine waters of Bangladesh by the Marinelife Alliance organization. From 1996 to 2008, ex situ conservation was practiced at St. Martin Island and in situ initiatives were implemented at a few spots at Sonadia and St. Martin Island. Until 2008, all activity remained within the coast of the southeastern district Cox's Bazar. Since 2009, we expanded our effort to sandy beaches at Chittagong. The estimated olive ridley and green turtle nesting on these long beaches of Cox's Bazar and Chittagong is estimated to be high. Major sea turtle conservation and research activities conducted by the Marinelife Alliance include monitoring nesting activity and stranded sea turtles, habitat mapping, conservation through the participation of community people, and education in local institutions. Outreach and general awareness among the community, including fishermen, is a regular activity. As part of the established conservation effort, Marinelife Alliance set up several sea turtle education and research centers along the coast to train community people and university students, developing capacity to carry on science based sea turtle research and conservation. A genetic study, tagging, and satellite tracking is being conducted through the support of international scientists, while valuable science based information is still to be explored to mitigate threats in offshore areas from marine fisheries.

*STANDARDIZATION OF LONG SERIES DATA ENABLED COMPARING SANCTUARY AND INHABITED NESTING SITES OF MARINE TURTLES IN THE SOUTH WEST INDIAN OCEAN

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The South West Indian Ocean (SWIO) is an important nesting and feeding ground for marine turtles. Nesting marine turtles have been monitored for more than twenty years in the French Eparse Islands, which are classified as sanctuaries, and for nearly ten years in two inhabited islands, Moheli (Comoros) and Nosy Iranja (Madagascar), where local communities are involved in monitoring and protection of these species. Long series data were gathered into different databases for each studied country, which evolved independently as protocols also evolved according to specific needs of the sites. Unfortunately the incompatibility of the data format collected today does not allow for reliable comparisons at a regional scale. To allow a robust regional analysis of the data collected, a common standardized database (TORSOOI) enabling data centralisation was developed on the basis of the existing databases. Linked to this database, a GIS database helped to prepare a synthesis of turtle distribution according to the characteristics of their nesting habitat, including human activities. Around 280,000 tracks and 22,500 mark-recapture datapoints were recorded in the four Eparse Islands and around 155,000 tracks and 15,100 mark-recapture datapoints were recorded in Moheli and Nosy Iranja. Comparisons between inhabited and sanctuary islands revealed that in some places, turtles and human beings can share the same environment. Nevertheless, this can be effective only with a strong awareness and involvement of local communities in marine turtle protection and conservation. Participating in marine turtle conservation can also create a source of income and benefit to the development of these communities.

NESTING BEACHES IN THE ANDAMAN AND NICOBAR ISLANDS: A PROFILE

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We present information from our 15 years of sea turtle surveys and research in the Andaman and Nicobar islands. We present consolidated information on the geography and habitat range across the islands of the Andaman and Nicobar archipelago that include sea turtle nesting beaches. This work has brought in additional information on species that use similar habitat, as well as beach preference by the four species of sea turtle (*Eretmochelys imbricata*, *Chelonia mydas*, *Dermochelys coriacea*, and *Lepidochelys olivacea*) that nest in the Andaman and Nicobar Islands. Along this geographic range we elucidate factors that influence sea turtle arrivals to nest at beaches as well as the management problems at hand. We briefly discuss our involvement in environment education and issues we grapple with in regard to sea turtle conservation in the archipelago.

THE RECOVERY OF NESTING HABITAT: CONSERVATION CHALLENGES FOR OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS OLIVACEA*) ON ORISSA COAST

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Sea turtles have evolved a variety of remarkable strategies for their survival and have flourished for millions of years. They use a wide range of habitats (sandy beaches, coral reefs, sea grass beds, etc.). Today, their numbers show tremendous decreases, such that all species have been assigned status ranging from 'threatened' to 'critically endangered'. Disturbances that these turtles face include human activities such as pollution, fishing and incidental capture, and habitat loss. These occurrences have been found to impact every stage of their life cycle. The olive ridley is indeed affected by all of these stresses but in particular it is affected by the loss of nesting habitat. The three mass nesting and sporadic olive ridley nesting sites are challenged by both unnatural and natural forms of habitat loss. Within the past century, humans have modified the beach by reducing the amount of native vegetation. Reduction of intact vegetation has contributed to habitat loss through coastal erosion, further complicating the turtle's ability to successfully nest. Erosion is becoming a significant problem in Orissa. Planting of indigenous species has been designed as an instrumental conservation measure to return critical native flora and preserve existing sandy beaches and sand dunes that are essential to nesting success. This has been created as a tool to integrate critical habitat needs of the olive ridley with human economic and developmental needs. Implications for sandy beach habitat restoration will be examined through an analysis of alterations in nesting distributions along with nesting beaches before and after the planting of the vegetation. An understanding of successful restoration attempts will help in the formulation of effective conservation measures for olive ridley nesting habitats in Orissa.

*TURTLE NIGHT WATCH NATURE TOURISM: SHARING BENEFITS TO SUSTAIN THE LOCAL COMMUNITY AND SEA TURTLES IN REKAWA, SRI LANKA

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The Turtle Conservation Project (TCP) selected Rekawa village for the implementation of the TCP's community based in-situ marine turtle nest protection programme in association with the Department of Wildlife Conservation (DWC). Rekawa is one of the Sri Lanka's most important marine turtle nesting sites as all five species of turtles which nest in Sri Lanka are found here nesting throughout the year. The TCP employs former turtle egg poachers as turtle nest protectors and provides them compensation in appreciation of their work. Later these nest protectors were grouped to form a community based organization called 'Nature Friends of Rekawa (NFR)'. In 1996, TCP introduced a nature tourism programme in Rekawa called "Turtle Night Watch" as a self sustainability event. The

aim of turtle watch is to create an additional income to support the local community in Rekawa, to continue TCP's community based conservation efforts and to support the Department of Wildlife Conservation. In 1998, with the assistance of Sri Lanka Tourist Board (SLTB) and Sri Lanka Hotel School, TCP trained a selected group of local people as "Tourist Guides", which resulted in them receiving their Guide Licenses. These guides were then employed on the beach and visitors paid a fee to experience the turtle watches in Rekawa. The profit of the 'Turtle Night Watch' nature tourism initiative has been shared by the stakeholders of the project. 10% of the tourism income has been allocated to the Rekawa community tourist guides and another 35% to a "Turtle Conservation Fund" that will cover the future salaries of the nest protectors when funding gaps occur. In addition, 25% was allocated to the NFR, 10% to the community welfare fund, 10% to the DWC and lastly 10% to the TCP to continue their conservation and other community programmes in Rekawa. In 1998 TCP started to collaborate with the Sri Lanka Tourist Board on a training programme for the local guides. During the tourism period of 2002-2003 (during the cease fire period), a sum of Rs 10,5000.00 has been raised from the Rekawa Nature tourism programme. This programme has won several global awards in the appreciation of services provided to the community, environment, and economy and to the visiting tourists.

REGULATION TO RESTORE ECOSYSTEMS – MARRYING FISHERMEN'S LIVELIHOODS AND TURTLE CONSERVATION IN ORISSA COAST

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This paper illustrates how a participatory and constructive approach can combine conservation with development, as is being attempted on the Orissa coast regarding olive ridley turtles, an endangered species. Five species of sea turtle inhabit Indian waters, of which the olive ridley is the most famous with high concentrations in Gahirmatha beach, a marine sanctuary area. Mating, mass nesting and hatching occur from November to May, peaking from January to March every year. In India, all five species of sea turtle are completely protected and included in the 1972 Wild Life (Protection) Act, Schedule-I and CITES Appendix I, both of which ban their capture and killing. An average of 700,000 to 800,000 olive ridleys nest every year in Orissa in three sites (Gahirmatha Marine Sanctuary, Rushikulya and Devi rookery) while the other four species nest periodically all along the Indian coast. In order to ensure further conservation and safety of the olive ridley, at present there is a temporary ban on fishing during the entire breeding migration period from November 1 to May 31. Imperiled livelihoods have agitated the fishing community into protesting prohibition on marine fishing along the Orissa coast, sometimes even resorting to violence. Loss of employment following the ban of marine fishing has led fisher people to migrate to other areas to live, and even some suicides in Gahirmatha. Trawlers were required to use Turtle Excluder devices (TEDs) but this has been mostly unimplemented and hence ineffective, like the recommendations of the Centrally Empowered Committee (CEC). Governmental efforts to compensate fishers for the loss of livelihood are still slow and inadequate while industries have recently been invited to set up SEZ or port or polluting ship wreckages and oil spills near Paradip. Such ad hoc regulatory mechanisms are causing confusion and conflict between fisher people, trawlers, industry, and government, further fuelled by the media. On the other hand, the CELL project, a consortium of NGOs and CBOs, is trying to promote an eco-restoration approach with the community and even Government participation as viable. It is establishing artificial reefs using hollow cement blocks in shallow near shore water. It is known to have increased coastal productivity 5–6 times, as in Tamilnadu under the CELL and TN Government project in the last two years. The reef permits use of mostly hook and line and traps, these gears do not catch turtles so turtle mortality is totally avoided. The commercial value of fish caught is high due to its high quality and freshness. Hence, the revival of the fishermen's livelihoods is ensured. It benefits the traditional fishermen by keeping trawlers away to avoid damage to the net by entanglement. Marine ecotourism can also be promoted as an alternative livelihood option with scuba diving and snorkeling facilities, as is done in Lakshadweep Island.

*COMBINING INDIGENOUS ECOLOGICAL KNOWLEDGE AND SCIENCE TO DEVELOP NEW TOOLS FOR MONITORING SEA TURTLE POPULATIONS IN NORTH AUSTRALIA

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New methods of monitoring changes in sea turtle populations are badly needed. Commonly used methods for monitoring sea turtles use the number of females that nest on a set length of beach over a set time period to develop an index of population size. Turtle numbers are usually derived from counts of tagged females, nests or tracks. Such an index is not particularly robust as turtles rarely nest every year and consequently there are large variations in index size even while the underlying population may be stable. For populations not experiencing precipitous declines or increases, this index requires many decades of data to determine population trends. Such methods are also not particularly suited to locations such as north Australia where nesting seasons can extend over many months, nesting beaches are in remote inaccessible areas, large man-eating crocodiles render night beach work highly dangerous, and where there is little or no infrastructure to support research and monitoring teams. Further, there are numerous sea turtle populations in northern Australia for which no baseline data exist, and the challenge of mounting and maintaining a monitoring program for decades is likely to be insurmountable. New methods and a new program for monitoring turtle populations are required, and the growing workforce of Indigenous sea rangers across remote and regional north Australia is the key to its success. The North Australian Indigenous Land and Sea Management Alliance's Dugong and Marine Turtle Project is working with Indigenous rangers and researchers to combine traditional knowledge and scientific methods to develop boat based survey tools to monitor sea turtle populations. Based on the renowned CyberTracker software, NAILSMA's I-Tracker network is creating data collection, analysis, and reporting tools that will allow locally collected survey data to be shared across north Australia and thus inform both local and regional management decision making. The paper will discuss the development of these new approaches, results to date, and the implications for improved marine and coastal management and Indigenous livelihoods in remote and regional north Australia.

CONSERVATION OF GREEN TURTLES: COMMUNITY BASED INITIATIVES AND MAINSTREAMING BY PAKISTAN WETLANDS PROGRAMME

A. Khan

Pakistan Wetlands Programme/WWF Pakistan

Lack of understanding of key environmental principles and issues in developing countries is one of the key factors in putting environmental issues behind the screen. This problem arises from gaps in research and knowledge management for a wider application by practitioners. This is exacerbated by various other factors such as lack of capacity, inaccessibility, and lack of political will. Makran Coast in Pakistan provides nesting areas for green turtles whose range is shared among various countries. Construction of the Gwadar Deep Sea Port in Gwadar and access provided through the Makran Coastal Highway have increased the rate of development, placing these sites under threat. The Pakistan Wetlands Programme has recognized the situation and has been working with the local authorities, local communities and other stakeholders for the conservation of green turtles on the coast. This paper will focus on green turtle nesting activity status on Makran Coast, their migration patterns and findings on range States, presenting conservation measures adopted by the Pakistan Wetlands Programme.

*INSULAR CARIBBEAN SEA TURTLE NESTING BEACHES AND EFFECTIVELY MANAGED PROTECTED AREAS

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In just over half of the 23 insular Caribbean countries and territories, locally occurring sea turtles are afforded complete protection through domestic legislation – including national fisheries policies and protected area management plans – and multilateral environmental agreements, such as international conventions. However, the remaining nations and territories currently have regulatory regimes in place that allow for seasonal fisheries of one or more species. In some areas where the exploitation of breeding adults has been abolished and other legislative means aimed at sea turtle protection have been put in place, data show increases in local nesting populations of several species within a comparatively short time. As such, strengthening regional protected area networks is a critical complementary step to the implementation of effective national legislation initiatives aimed at conserving sea turtle populations. The Caribbean Challenge is just such an initiative, with Caribbean governments committing to support and manage new and existing protected areas throughout the region, with the aim to conserve at least 20 percent of marine and coastal habitats by 2020. As the Caribbean Challenge progresses, we sought to (i) compile the most up-to-date information on protected areas for the insular Caribbean, (ii) quantify the amount of nesting habitat currently located in protected areas, and (iii) present the amount of nesting habitat under varying national sea turtle legislation and different levels of management effectiveness for five countries and territories for which Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) surveys have been completed (The Bahamas, Jamaica, Grenada, US Virgin Islands and St. Vincent and the Grenadines). RAPPAM methodology provides potential management effectiveness based on the themes of governance, planning and resources. Data suggest that approximately 30% of sea turtle nesting habitat resides inside countries and territories that currently afford its complete protection. Similarly, 30% of sea turtle nesting habitat for the insular Caribbean also occurs inside protected areas. However, of the total number of nesting beaches inside protected areas few are managed effectively. Future analysis will expand beyond nesting beaches to look at essential sea turtle foraging habitat and whether it falls under legislation guaranteeing its effective management and/or protection.

*PEOPLE, PROGRAMS, AND POVERTY: THE HUMAN ELEMENT IN SEA TURTLE CONSERVATION, NELLORE COAST, ANDHRA PRADESH, INDIA

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This paper illustrates the methods used by TREE Roots & Shoots Nellore for olive ridley sea turtle conservation in Nellore, Andhra Pradesh, India during 2008–2009 and 2009–2010. The olive ridley (*Lepidochelys olivacea*) nests on the Nellore coast, while juvenile hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) forage in the ocean of the study area, as documented during the pilot project conducted in 2008–2009. No conservation measures had been initiated in Nellore until 2008 and the local communities were unaware of the protection laws and importance of the turtles in the coastal marine ecosystem. There was an urgent need to protect the ridley nesting sites along the coast and adult olive ridley turtles en-route to the mass nesting beaches of Orissa. It was also imperative to reduce fishery related mortality to the juvenile hawksbills and green turtles foraging in the marine habitat before the turtle populations collapsed. While the effectiveness of Integrated Conservation and Development Programs continues to be debated, the importance of working with the people living in coastal areas which are also sea turtle nesting sites remains undisputed. Determining the best way to involve local people and improve livelihoods, while at the same time promoting a conservation agenda in this rural coastal area was a challenge. Most conservation programs are striving to include a "human component" in their conservation initiatives

in India. Conservation programs incorporate the human element from a variety of perspectives including: education programs, capacity building, ecotourism, economic development/poverty alleviation, and human and animal health programs, to name a few. The presentation will focus on initiatives that combine conserving species and habitat with empowering local people and networking with the Department of Forest (Wildlife Wing) and the Department of Fisheries as well as on best practices and lessons learned as we move forward in developing holistic a marine conservation programs. The training and involvement of local young fishermen as Sea Turtle Protection Force (STPF) members (monitoring nesting turtles, relocating eggs into hatcheries, providing protection from poachers and predators and spreading the conservation message to community members) was the pivotal factor of the program.

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*DEVELOPMENT OF A USER-FRIENDLY KEY TO IDENTIFY INDIVIDUAL GREEN SEA TURTLES (*CHELONIA MYDAS*) FROM PHOTOGRAPHIC RECORDS

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The need to identify individuals in a population is essential for much population-based research, including conservation. For large, long-lived species, tagging over the course of a lifetime is problematic due to tag loss, relocation and readability of the tag, cost and the invasive techniques that are often needed. The use of natural markings to identify individuals is a growing area of research. Although it has been used successfully for a long time in cetacean surveys, it is only recently being used for other large marine animals (e.g. whale sharks). Unlike the spots of whale sharks, sea turtles have more variability in the types of characteristics that can be used for identification. For example both scale and scute characteristics are available, which vary in terms of their number, shape and presence of 'ticks' or dots on the head and carapace. It is the combination of these characteristics that makes each individual unique. As such, identification keys that take account of the many different traits exhibited by turtles are the most appropriate method for classifying individuals. This study examines methods for the development of such a key using either live turtles or photographs. For a key to be useful, it must be as complete as possible (i.e. distinguish between the maximum number of individuals) but also be intuitive and user friendly. This means a balance between using the simplest characteristics to distinguish between individuals, but also partitioning the population to the maximum extent during each step (essentially keeping the key short). To identify the possible completeness of the key, we use cluster analysis techniques to show that the characteristics to be included are suitable. We then present a computational method based on selecting the maximum variability for each characteristic over a population of green sea turtles (*Chelonia mydas*) studied in Akumal Bay, Quintana Roo, Mexico. In conjunction with the maximum variability of each characteristic a 'priority' was allocated to it. This priority indicates the ease of distinguishing the characteristic from a photograph of an individual (e.g. a suitable starting place may be the number of parietal scales, not the presence of spots on the base of the neck, only visible in some photographs). The development of a key to identify individual turtles will allow researchers to monitor individuals over large temporal and spatial scales. Combined with modern technological advances (such as the inclusion of GPS recorders in mobile phones and cameras) this could allow both scientists and 'citizen scientists' (especially tour guides) to collect data and share over internet databases. This would allow global population levels as well as further information on behavioural ecology such as migration routes to be established.

*SEA TURTLE CONSERVATION DURING THE NEXT 100 YEARS: A SPATIAL ANALYSIS OF NESTING BEACH VULNERABILITY

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Climate change is a major threat to wildlife, habitats, and human populations and will manifest itself in coastal and marine ecosystems through rising seas, elevated water and air temperatures, changing ocean currents, and greater storm intensity. These consequences have the potential to be especially perilous for sea turtles, which rely on stable beach morphology and narrow temperature envelopes for successful nesting and reproduction. Already, human population growth and development along shorelines encroach on turtle nesting beaches and soon rising sea levels will apply pressure from the other direction as well. Scientists at World Wildlife Fund, along with academic and NGO partners have quantified this coastal vulnerability for hawksbill turtles at 10 field sites throughout the insular Caribbean Sea. We used spatial modeling, GIS, remote sensing, and primary field data to predict which beaches and islands will be most susceptible to rising sea level, higher temperatures, and altered currents. These results should serve as a road map for sea turtle conservation in the Caribbean by pointing to those nesting habitats that are most threatened and setting the foundation for climate adaptation and mitigation work. This research can be modified for conservation of other species of sea turtle and in other regions of the world and may prove an important component of coastal planning as communities living near the sea increasingly face climate change-related impacts of their own.

HATCHING SUCCESS OF *DERMOCHELYS CORIACEA* THROUGH THE TRANSLOCATION OF EGGS

Marga Lopez

Endangered Wildlife Trust, Limon, Costa Rica

The Endangered Wildlife Trust (EWT) is an organization that was founded in 1989 which conducts studies and works for the conservation of sea turtles (*Dermochelys coriacea*, *Chelonia mydas*, and *Eretmochelys imbricata*). The most important of their three existing projects is Pacuare Reserve in Costa Rica which has been operating and monitoring leatherback nesting patterns for the past fourteen years. Two similar nesting conservation programs have been started in Panamá: Playa Soropta and Playa Larga, Bastimentos Island. Although they are only four years old, both conservation projects have been largely successful. In this study we have compiled and analyzed data on the occurrence of nesting turtles, hatching success and percent of hatching in relocated eggs. Through comparative analyses of egg transport time and percent of successful hatchings, one is able to see the influential impact of egg translocation on the overall success of the leatherback turtle species. This study enables scientists to improve strategies to increase neonate populations each year. Pacuare Reserve is Costa Rica´s most important beach for leatherback nesting. This can be seen through data collected in the past fourteen years. 2009 has been the most important in leatherback nesting, resulting in a net total of more than one thousand spawn. With respect to this rise in nesting, the results due to the years of protection have been extraordinary, resulting from a previously large scale of kills and unchecked poaching. These projects are getting increases in nesting each year and for one of the most important nesting places on the Caribbean Coast.

DETERMINATION OF PEAK NESTING SEASON OF GREEN TURTLES IN THAMEEHLA ISLAND, MYANMAR

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The Union of Myanmar is an Asian country rich in diverse aquatic organisms including sea turtles. The sea turtle species recorded in Myanmar are loggerheads (*Caretta caretta*), green turtles (*Chelonia mydas*), hawksbills

(*Eretmochelys imbricata*), olive ridleys (*Lepidochelys olivacea*), and leatherbacks (*Dermochelys coriacea*). Since 1963, the Department of Fisheries (DoF) has taken up a project to propagate and conserve sea turtles. Then in 1986, the project was fully revived and a hatchery was established in Thameehla Island, Ayeyarwady Division. As sea turtles are recognized to be one of the most seriously endangered in the world, DoF is also planning to set up new units exclusively for sea turtle conservation management in its new organization set-up. Thameehla Island is a major green turtle nesting site in the Ayeyarwady delta. Nesting occurs year round on Thameehla Island and it is considered to be a migratory pathway and foraging area for green turtles. In Thameehla Island the Department of Fisheries is taking conservation measures that include research and monitoring, including translocations of eggs to hatcheries. Data collection on hatching success at the original nest site is also carried out. Some turtle nests located in unfavorable environments were collected and incubated in hatcheries and later released in the sea. Total number of laid eggs, un-hatched and damaged eggs and hatchlings released were recorded. In this study, hatching practices and methods were described and discussed and the peak nesting was determined. The study was carried out from 2001 to April 2009.

MAPPING GREEN TURTLE NESTING BEACHES IN THE CENTRAL AND WESTERN PACIFIC

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Green sea turtles in the Pacific Ocean are widely distributed, likely nesting at hundreds of sites among the thousands of islands and atolls scattered throughout the Central and Western Pacific Ocean. Very little information exists regarding stock structure, abundance, or trends for populations in this vast region. However, a range of nesting records and survey information is available in published documents, gray literature, and in-country government reports gathered over the past 30 years representing varying degrees of effort and consistency. In an effort to develop a tool for marine turtle resource management, the National Marines Fisheries Service Pacific Islands Regional Office (PIRO) Protected Resources Division (PRD) has undertaken a mapping project and literature review to better understand the distribution, habitats, and status of green turtles in the Central (excluding Hawaii) and Western Pacific. Using GIS software, 170 nesting site locations were mapped and grouped into 25 nesting aggregations (NAs). These NAs were delineated using a combination of genetics information (where available) and proximity of rookeries to each other based on the geographic extent of genetic exchange reported for Pacific green turtles in previous research. Annual nesting female abundance estimates and any available trend information were compiled for each NA where possible. These NAs do not represent recovery units recognized by the Endangered Species Act, but were delineated by PIRO PRD resource managers using the best available information to allow for an organized and manageable synthesis of existing data on green turtle nesting locations, abundance, and trends in the region. They also serve to facilitate the identification of gaps in current information and to help prioritize and direct future research, management activities and international collaborations throughout the Pacific.

THE COAST OF CAPE VERDE CONSTITUTES THE THIRD LARGEST LOGGERHEAD NESTING POPULATION IN THE WORLD

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Extensive sea turtle nesting monitoring has been conducted in several islands of the Archipelago of Cape Verde during the past years. The loggerhead turtle is the only species that nests in these islands though green and hawksbill turtle juveniles are very often found feeding around their coasts. Around 90% of loggerhead nests are deposited in the island of Boavista on approximately 50 km of white sandy beaches. This is one of the less populated islands with more inaccessible beaches, as all villages are far from the main nesting areas. Another 9% of nests are equally distributed among the islands of Sal, Maio and San Nicolau and the remaining 1% of nests are found among the

other six major islands and several islets of the archipelago. Consumption of sea turtle meat is a traditional practice in the Cape Verde Archipelago despite international and national sea turtle protection laws. Thus, the slaughter of nesting females on the beaches is very intense and threatens the survival of the population. During the past decades, female hunting has almost extirpated loggerhead nesting from several Cape Verdian islands and hunting pressure has significantly increased in Boavista. Since 1998, the NGO Cabo Verde Natura 2000 has monitored and protected the loggerhead population in the high nesting density area (60–65% of nests) of the Archipelago from the International Volunteer Sea Turtle Conservation Camp of Ervatão. In 2009, Cabo Verde Natura 2000 established a new sea turtle conservation camp in Porto Ferreira beach, starting the protection of the second largest nesting area in the island. From both camps, CV Natura 2000 is now efficiently protecting more than 80% of nesting. During the last three years, we have estimated a total number of nests at Boavista of around 13,500 (2007), 12,800 (2008) and 20,500 (2009). Nest counts were conducted daily on beaches patrolled from the two international camps, including between 65% (2007 and 2008) and 80% (2009) of nesting. The rest of the beaches were surveyed periodically and the total number of nests was extrapolated with daily counts. These data demonstrate that nesting levels in this isolated western African population are much higher than expected and indicate that the coast of Cape Verde is the third largest nesting aggregation in the world, after Florida and Oman. Nests in Cape Verde also constitute more than 95% of loggerhead nesting in all eastern Atlantic coasts. The distribution of nesting is not homogeneous on the island. We have identified a very important 10 km stretch of beach in southeastern Boavista that holds 60–65 % of nesting activity. Approximately 90% of nests are found on the beaches of the eastern half of the island. Nest density can be very high on some beaches with records of up to 2.0 nests per meter at the end of the nesting season on several beach sections longer than 800 m.

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*COMMUNITY-BASED DEVELOPMENT AND ITS APPLICATION TO SEA TURTLE CONSERVATION IN BAHIA DRAKE, OSA PENINSULA, COSTA RICA

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The Corcovado Foundation is a nonprofit organization that has worked for 10 years for the conservation of the natural resources in the Osa Conservation Area in Costa Rica. One of the main lines of work is its community development program. Previous experiences in other turtle projects have shown the importance of having the local communities empowered and understanding that their future depends on a responsible management of their natural resources. As a result, in 2006 the Playa Drake Sea Turtle Conservation Project located in El Progreso, a small village on the Southwestern coast of Costa Rica, was created. Four of the world's seven species of marine turtles come ashore to nest on the Osa Peninsula. These are the black turtle (*Chelonia mydas agassizii*), the olive ridley (*Lepidochelys olivacea*), the leatherback (*Dermochelys coriacea*), and the hawksbill (*Eretmochelys imbricata*). In four years the project has helped reduce the poaching rate by 95%. For at least a decade the community faced a huge poaching pressure, taking the turtle population almost to extinction. Environmental education activities in order to create awareness in the communities, turtle management training and community development efforts make the protection of turtles a sustainability issue. One of the products of these efforts is the constitution of ACOTPRO (the Association of Conservation of the Marine Turtle of El Progreso) that aims to protect marine turtles and at the same time intends to generate additional income for the families involved in the turtle protection through ecotourism. The search for economic alternatives by a non-predatory use of the turtle resources is showing great results in order to obtain a self-sustainable project. We understand that the best option for viable, long term protection of the marine turtles lies in the hands of the communities.

A SURVEY OF SEA TURTLES IN THE EAST COAST OF SRI LANKA TO ASSESS THEIR CONSERVATION STATUS

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With a coastline extending 1,340 km and consisting primarily of vast sandy beaches, Sri Lanka would have been an important nesting area for sea turtles from prehistoric times. Within the past 100 years there have been tremendous changes to the coastline physically and qualitatively. The 2004 tsunami caused severe damage to two thirds of the island's coastline. The impacts of these changes on sea turtles are unknown. The east coast is one of the least studied areas, which for the past 27 years has been inaccessible to researchers due to terrorism. When compared to the western and southern coasts, where more data exist on turtles, a lack of primary and secondary data for the east coast has resulted in having no baseline information to formulate conservation actions. To address this, in August 2008 the Sri Lanka Wildlife Conservation Society, in partnership with the Panama Environmental Explorers Society, initiated interviews in Ampara district and surveys along the coastline from Arugambay to Panama (N 6°51´ and E 81°49´30" and N6°40´ and E 81°6´30") in the Eastern Province. Time lap patrolling was conducted every hour to collect information on sea turtles, nests, poaching, predation and other human activities on the beaches. When a track was located, the following information was recorded: nesting or non-nesting incident, eggs predated, poached or still in the nest, species, and GPS point of the nest. From November 1st 2008 to March 9th 2009 a total of 54 beach patrols were conducted from Arugambay to Panama Lagoon mouth, a distance of about 11 km. A total of 45 nesting incidents were recorded. Of these 45 nests, 8 were erased by wave action, 22 were predated by wild boars and 10 were robbed by poachers, and 5 nests were provided with nest protection devices. Eighty percent of the nests were destroyed either by poachers or predators leaving only 11% of the nests to hatch. Of these nests, 49% of the nests were destroyed by wild boars and 22% were robbed by poachers. From March 23rd to April 9th 2009, 31 beach patrols were conducted and 4 nests were located and naturally protected in-situ. Due to increased patrolling, out of a total of 49 nests only 20% of nests were robbed by poachers and 45% were predated by wild boars increasing the number of nests that had a chance to hatch to 18%. Of the 5 nests that were protected, 300 hatchlings emerged from 4 nests while one nest was destroyed by waves. Poaching and predation have a tremendous impact on sea turtles and they are highly vulnerable. Basic conservation actions such as beach patrols and in-situ nest protection devices can have an immediate impact in minimizing predation and poaching. Off shore fishing and lobster nets become physical barriers to nesting adults and hatchlings. During the surveys two dead juvenile green turtles and one adult olive ridley were encountered. An environmental education and awareness program was conducted for 320 students in four government schools in the area.

*APPLICATION OF EXPERT PANELS FOR MARINE TURTLE MANAGEMENT: LEARNINGS FROM A MARINE TURTLE EXPERT PANEL IN WESTERN AUSTRALIA

Dorian Moro

Chevron Australia, Western Australia, Australia

This talk focused on the terms of reference, role, composition, consultation, and involvement of an expert panel as an advisor to an oil and gas Proponent (Chevron Australia) on managing a population of flatback turtles (*Natator depressus*) in close proximity to their development. One of the challenges faced by the Proponent in commercialising their development (the Gorgon Gas Project) is the location of the gas processing facilities on an important conservation reserve (Barrow Island off the coast of north western Australia), and immediately adjacent to a regionally important rookery of flatback turtles. Significant impacts to this population in the course of the construction and operation of the project could alter nesting behaviour of adults using the beaches, or hatchlings which depart the beaches and inshore waters. However, industry and specialist consultants are confident the risks and known potential impacts to this population can be managed. There lies the challenge: how to develop an important economic resource (gas) while protecting the conservation values of this marine species. After an extensive impact assessment process the State and Commonwealth Ministers for the Environment granted project approval subject to a range of stringent conditions. One of the conditions was the establishment of an independent

Marine Turtle Expert Panel (MTEP) to provide advice to the State Minister for Environment and the Proponent, to assist with the successful planning and execution of the Project's construction and operational activities and associated marine turtle management requirements. The MTEP comprises a membership of independent experts, consultants, and representatives from regulatory authorities and the Proponent. The MTEP was developed on the basis that it would allow a balance to be reached between managing the risks to turtles, and allowing a major development to proceed for resource extraction. This presentation drew on the Proponent's experiences through its involvement with the Gorgon MTEP. From its involvement with similar advisory committees and expert panels, the Proponent was confident the experience of dealing with a high-caliber group of specialists would have a beneficial contribution to the development of proposals to eliminate or reduce impacts to marine turtles as a result of their project. Over the course of 10 months the Gorgon MTEP met numerous times; holding various multi-day meetings and workshops and conducting a site visit to Barrow Island to exchange information, review draft documentation and provide advice. Management of the MTEP was facilitated by an independent Chair, with the support of a Secretariat, to foster strong transparency and ensure environmental protection and project development objectives were met. The MTEP has to date focused on the development of a Long Term Marine Turtle Management and Monitoring Plan, which the Proponent believes establishes a new benchmark of how industry in Australia can manage their potential impacts on marine turtles. Key experiences and lessons were discussed so that future practice in the use of such expert panels by other organisations can be applied and optimised.

*LOCAL INITIATIVES FOR THE CREATION OF A NETWORK OF STAKEHOLDERS FOR THE CONSERVATION OF MARINE RESOURCES IN MOHELI MARINE PARK (COMOROS UNION)

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The development of local initiatives in favour of the environment in Mwali (Comoros Union) shows an awakening to the richness which biodiversity represents. At the beginning of the 1990s, local communities compensated for the disengagement of the central Government by creating one association (Ulanga) with specific aims in each village. They then gathered within a federation "Ulanga Mwali". The cooperation between these associations and regional and international funding allows the development of projects based on conservation and management of natural resources. Twenty years later, some of these initiatives still work, when local interest converges with external partner and funding interests. Eco-tourism based on sea turtles in Itsamia or on Levingstone's bat in Hoani, the Marine Park of Mohéli and the Ecotourism house of Mohéli serve as an example of how the sustainable development of Mwali and in the Comoros Archipelago can be ensured. Itsamia hosts the first site nesting for green turtle to the Indian Ocean, and the local NGO ADSEI has worked with Kelonia Reunion since 1998. It is an occasion to share the experience of the local community of Itsamia to protect green turtles and to learn how the local NGO can manage this resource.

CRAWL COUNTS AS A MANAGEMENT TOOL – OLIVE RIDLEY POPULATION TRENDS ON THE PACIFIC COAST OF GUATEMALA

Colum Muccio, Eduardo Merida, and Eva Oleksinska

ARCAS, Guatemala

The Wildlife Rescue and Conservation Association (ARCAS) is a Guatemalan NGO coordinating an integrated coastal zone management effort in the Hawaii area of the Pacific coast of Guatemala, Central America. As part of its sea turtle conservation program, it has been conducting crawl count surveys since 1997 in an attempt to determine nesting density and long-term population trends of the olive ridley and leatherback sea turtles nesting in the area. ARCAS has also led efforts to improve and standardize data-gathering and management efforts at the other 19 hatcheries operating along the Pacific coast and is a founding member of a consortium of sea turtle hatchery administrators on the Pacific coast of the country named Project Parlama (the local name for olive ridleys). Using crawl count data as well as data gathered in the course of the management of its hatcheries, ARCAS and Project

Parlama hope to: 1) establish baseline data and determine population trends along the entire coast; 2) monitor local compliance with voluntary egg donations; and 3) determine the adequacy of current sea turtle conservation strategies and make policy recommendations for the future. ARCAS follows a policy of information-sharing and hopes to document the importance of egg collection in the local culture and economy and guide future policy towards a balanced approach that meets both social and conservation needs.

*OLIVE RIDLEY TURTLE NESTING GROUND SUITABILITY ANALYSIS USING SPATIAL INFORMATION SYSTEMS

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Olive ridley turtles are known for mass nesting aggregations known as arribadas. The East Coast of India is one of the major nesting sites for olive ridley conservation. Other than Orissa, the coastline of Andrapradesh and Tamilnadu State also provides favorable conditions for turtle nesting activity. At present olive ridley nesting populations have declined due both to killing of nesting females at solitary nesting beaches and to a directed fishery. Loss of nesting habitat resulting from erosion control through beach armoring (like seawalls and boulders), beachfront development, artificial lighting, and non-native vegetation is a serious threat affecting nesting females and hatchlings. This paper will elucidate the study conducted along the Chennai, Kancheepruam coast in 2009–2010. Spatial Information Technology is a useful tool for turtle conservationists. The paper will explain how GIS supports conservationists in better understanding ecosystem changes in protected areas. GIS is often used for land suitability analysis which is helpful for monitoring the specific nesting grounds. With the help of satellite imagery, sea walls, boulders and vegetation near the shoreline can easily be marked. Global Positioning System data and satellite imagery will be used for demarcation of the high tide line, nesting sites, hatchery placements, endemic vegetation and presence of dunes. Other important parameters such as Sea Surface Temperature (SST), humidity, tidal height variation, phytoplankton and rainfall will also be considered for this suitability analysis. Turtle nesting is a critical task from a conservation point of view. There are several physical factors affecting the nesting habitat. As a result, conservationists need the support of science and technology. This research intends to explore the effectiveness of Remote Sensing and Geographical Information Systems in monitoring nesting grounds and study their suitability. Suitability of the nesting grounds and factors affecting the nesting of turtles in the district are the expected output.

*EFFECTS OF ANTHROPOGENIC CHANGES TO THE RUSHIKULYA NESTING BEACH ON OLIVE RIDLEY SEA TURTLES, ORISSA

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The effects of *Casuarina* plantations on turtle nesting beaches has been widely debated regarding their effects on the geomorphology of the beaches, light barriers to prevent hatchling disorientation, nest predator refuges, etc. Here, we investigated the effects of lighting and hatchling disorientation in the various sections of the mass nesting beach as well as the levels of nest predator presence and activity during the peak nesting season of the olive ridleys at Rushikulya in Orissa (Dec 2008–May 2009). Using track plots laid across the nesting beach, predator presence and activity was calculated using a Passive Tracking Index (PTI) developed by Engeman *et al*. Hatchling orientation along the beach was checked by laying five orientation arenas along the beach stretch and testing for the strength as well as angle of orientation. Areas with *Casuarina* plantations immediately backing the nesting beach had minimum hatchling disorientation but were the areas that supported maximum predator presence and activity throughout the nesting season. Even though *Casuarina* effectively shield the beach from light and reduce hatchling disorientation, our results show higher levels of predator presence along these sections. These results from our study have given another insight into the effects of extensive *casuarina* plantations along high density nesting beaches along the Indian coast. In such a situation, where even the currently practiced technique of fencing areas flanked by plantations doesn't seem very effective, we suggest a more active predator control strategy.

INFLUENCE OF INCUBATION TEMPERATURE ON SEX RATIO IN SAL ISLAND (CAPE VERDE)

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Loggerhead sea turtles (*Caretta caretta*) exhibit sexual differentiation determined by temperature. In particular, temperature defines sex ratio in a specific thermosensitive period, identified as the middle third of the incubation duration. According to previous studies, pivotal temperature differs among loggerhead populations, ranging between 28.6°C and 30.0°C. The aim of this study is to record how the temperature changes among different nesting beaches in Sal Island, the northeastern island of the Cape Verde archipelago and to assess the sex ratios of the nests laid in these beaches. Five temperature sensors, pre-programmed to record data every hour, were distributed at a fixed depth of 35 cm along the island. Three were installed to record temperatures throughout the nesting season in different nesting beaches (east coast in Costa da Fragata; west coast in Algodoeiro), and the other two were placed in two hatcheries, one located on the west coast (Algodoeiro) and the other south of the island, in Santa Maria. The temperature data downloaded from the loggers were then used to calculate mean temperature during the sex-determining period. Sex ratios were then predicted for each nest, by comparing the mean temperatures obtained with published data relating the incubation temperature with the percentage of hatched females. Preliminary results indicate that temperatures in the hatchery located on the west coast were considerably lower than the ones observed in the original beaches, while the temperatures from the other hatchery were higher than the ones from the original beaches. These results indicate that good knowledge of beach temperatures is crucial to maintain the natural balance of the population. Understanding the natural sex ratios for sea turtle populations in Sal Island will lead to better conservation practices during the process of nest relocation to hatcheries.

*SEA TURTLE CONSERVATION IN ACEH PROVINCE, INDONESIA: THREE YEARS OF PROTECTION AND MONITORING EFFORTS

Maggie Muurmans

Yayasan Pulau Banyak, Pulau Banyak, Aceh, Sumatra, Indonesia

Yayasan Pulau Banyak, a small local Indonesian NGO, started its conservation activities in 2006 and managed within three years to completely ban unsustainable egg take from the nesting beaches in Pulau Banyak, South Aceh, Indonesia. Full local support for the conservation programme has been obtained by offering community lending, eco-tourism activities, environmental education, waste management solutions and English teaching. Most activities have benefitted from the assistance of international volunteers. Through partnerships with organisations such as Seacology, conservation concessions have been part of protection strategies, not only for marine ecosystems but also for the pristine forests on the 40 islands of the archipelago, which contain rare species of birds, mammals and reptiles. The sea turtle monitoring programme, located on Pulau Bangkaru, has provided the first information on population status, migration and numbers of nesting female green (*Chelonia mydas*) and leatherback turtles (*Dermochelys coriacea*) through flipper tagging and nest counts. The programme protected 263 nests during the peak month and 44 nests during the lowest month on the 1.8 km beach of Amandangan. To increase protection efforts, the leaders of the Aceh Singkil regency signed a declaration (Maklumat Bersama) in October 2008 to prohibit the use of nets within 12 nautical miles of the main nesting beach. Yayasan Pulau Banyak is now working towards an increase in the protected status of Pulau Bangkaru and assists in writing management plans, including allocated zones for activities such as fishing, recreation and building. Through actively involving local communities and considering their development needs, sea turtle conservation has become part of their way of life. Within three years, a change in behaviour and awareness has been noticed throughout the coastal community of Pulau Banyak and local government bodies. Solutions to problems that have occurred during the programme have focused on

jealousy between villages, corruption, isolation and logistics. The success of the programme will be celebrated in 2010 with a sea turtle festival including competitions, music, dance and sports.

*AN OVERVIEW OF LEATHERBACK TURTLE RESEARCH AND CONSERVATION IN INDIA

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Information on leatherback populations from India is still very patchy. Though there are earlier records of sporadic leatherback nesting from the Indian mainland, current nesting populations are entirely restricted to the Andaman and Nicobar islands. Studies reported the leatherback nesting population in the Nicobars to exceed 1,000 individuals making it of global significance. Yet, in the absence of long-term monitoring of nesting patterns, our understanding of spatio-temporal trends in leatherback populations is rudimentary. The objective of the current study is to review the existing information and conservation efforts for leatherback turtles from the Andaman and Nicobar islands, try to identify gaps in existing baselines that are important for understanding long-term population trends and try to identify priority areas for research and conservation. Post tsunami leatherback nesting patterns in the nesting beach of South Bay, Little Andamans over the last two seasons (2007–2009) is also presented.

THE IMPORTANCE OF TEMPERATURE MAINTENANCE IN HATCHERY BASED OLIVE RIDLEY CONSERVATION ON THE CHENAI COAST, INDIA

Sabha Natesan and Supraja Dharini

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This poster attempts to demonstrate how temperature affects the hatching process of olive ridley sea turtle eggs. It is known that incubation temperature affects the sex ratio of hatchlings in sea turtles. The term “threshold temperature” is used to describe the incubation temperature at which the sex ratio occurs. Incubation temperatures are vital for effective hatchery management practices and restoring turtle populations. The study will be done in the hatcheries of five selected villages along 13 km of the Chennai coast to validate the 5 years of successful hatchling emergence in ex-situ hatchery management. The study will take place from December 2009 to May 2010 with the use of 10 temperature data loggers to ascertain the accuracy of temperatures within the nest, in the hatchery and outside the hatchery. Hatchling emergence and the ‘hatchling success’ numbers will be systematically and scientifically documented. The effect of placing loosely woven coconut leaves (a ‘thatch roof’) over the hatchery will be checked using a thermometer placed at a depth of 10 inches below the surface and validated through the use of temperature data loggers.

DETERMINATION OF THE PEAK NESTING SEASON OF OLIVE RIDLEY TURTLES IN GADONGALAY ISLAND, MYANMAR

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The Myanmar coastal areas harbour five species of sea turtle which nest regularly. They are olive ridley (Leik Hlaung), loggerhead (Leik khway), green (Pyin Tha Leik), hawksbill (Leik kyet Tu Yway) and leatherback (Leik Zaung Lyar) turtles. Since 1963, the Department of Fisheries (DoF) has taken up a project to incubate and protect sea turtles on Diamond Island in Ngaputaw Township, Ayeyarwaddy. Then, in 1986–87, the program was fully revived and more departmental hatcheries were established with skillful technicians. Myanmar began systematic sea turtle conservation and management activities in 1997. Gadongalay Island (15 H41'28.5”N, 95 H14'47.3”E) has existed since 1911. This island was formed with deposited sand. Turtles lay eggs on this island from September to March yearly. The Department of Fisheries has undertaken sea turtle conservation and research on Gadongalay Island since 1998. Gadongalay Island is one of the major nesting areas for olive ridleys (*Lepidochelys olivacea*). The study of olive ridley nesting activities was conducted at Gadongalay Island. Myanmar conducted the research to

conserve sea turtles and their nesting beaches and passed rules and regulations such as Myanmar Marine Fisheries Law (1999) and Myanmar Wildlife Law (1994). From December 2001 to 2008, the Department of Fisheries has recorded 360 nests, 41,701 eggs, and 35,709 hatchlings released. In this study, peak nesting season for olive ridley turtles in Gadongalay Island is also described and discussed.

THREATS TO SOLITARY NESTING OF OLIVE RIDLEY TURTLES (*LEPIDOCHELYS OLIVACEA*) IN AN EL NINO YEAR AT OSTIONAL, COSTA RICA

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The objective of this study was to determine the hatching success of solitary nests of olive ridley turtles on Playa Ostional, an arribada nesting beach in Costa Rica. Between the months of March to June 2009, the summer season in Ostional Refuge, we tagged 170 ridleys with an average carapace length of 67.2 cm and width of 71.4 cm. Those turtles laid a mean of 95 eggs in 12 minutes. We marked 53 nests in high, medium and low areas of the beach. At the time of the exhumations we found pupae, flies, worms, fungi, odor, and dry yolks in most nests. In addition nest chambers were interconnected with other new and old nests from arribadas, spreading contamination. Only 24 nests survived poaching, predation by dogs and high tides. Of the remaining 24 nests, only one clutch hatched and hatching success was 6%. Average nest temperature was 32.6°C from data loggers and 31.9°C from thermocouples. The presence of El Niño caused a lack of rain and high temperatures during the dry season. Combined with a large amount of decaying organic material these factors contributed to an unhealthy microhabitat for the development of eggs. Temperatures reached lethal levels for successful embryo development. In addition, a combination of natural and anthropogenic threats contributed to low hatching success for solitary nests of olive ridleys in Ostional. Acknowledgments: Special thanks to ISTS travel grants, the Department of Biology from Drexel University, the National Conservation Areas System (SINAC), Ministry of the Environment and Telecommunication of Costa Rica (MINAET), especially the Tempisque Conservation Area (ACT), and mainly the Ostional Wildlife Refuge and to the rest of the stakeholders. Equally to volunteers who collaborated collecting data.

CONSERVATION AND MANAGEMENT OF THE OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) SEA TURTLE IN NORTH ANDHRA COAST OF BAY OF BENGAL, INDIA

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The olive ridley sea turtle (*Lepidochelys olivacea*) is widely distributed in the tropics of the Indo-Pacific and East Atlantic Oceans. It is found all along the east and west coasts and Bay Islands of India. The olive ridley turtle is protected under Schedule-I of the Indian Wildlife (Protection) Act, 1972. The IUCN Red Data Book has assigned endangered status to olive ridley turtles for conservation of their populations. It is also cited in Appendix I of the Convention on International Trade in Endangered Species (CITES) which prohibits trade in turtle products among the signatory countries. Nesting populations of olive ridleys migrate from the Indian Ocean to Orissa beaches through the coastal waters of Andhra Pradesh during winter months (November to February) for mass nesting (arribada) activity. While migrating, a considerable number of nesting ridleys utilize the North Andhra Coast (16°50'-18°25' latitudes and 82°10'–84°10' longitudes) for their reproductive activity (courtship and nesting). Thus the Northern Andhra Pradesh Coast (NAC) is an important habitat for nesting olive ridley turtles apart from the mass nesting sites of Orissa coast. In recent times the breeding population of the olive ridley is exposed to various threats at different stages of their life cycle, including incidental catch in offshore waters and predation of eggs and hatchlings at nesting beaches. Besides exploitation of breeding ridleys for meat and tortoise shell, loss of nesting sites and foraging grounds causes rapid depletion of ridley populations. For conservation of olive ridley turtles along the North Andhra Coast, the following conservation strategies have been implemented based on their life cycle stages. To reduce incidental catches: implementation of Turtle Excluder Devices (TEDs) to reduce incidental

mortality of the migratory breeding population due to shrimp trawl fishing in offshore waters. Protection of nests, eggs and hatchlings: to avoid natural predation and inundation from high tides, vulnerable nests were relocated to nearby protected beaches for in situ conservation and safe release of newly born hatchlings into marine waters. Protection of nesting habitats: to protect nesting beaches and foraging habitats from human developmental activities (such as alterations and pollution of marine waters) and to create awareness among the fishing community to avoid traditional exploitation of the breeding population for livelihoods in the subsistence economy.

LOGGERHEAD REMIGRATION ANALYSIS: IMPLICATIONS FOR FORAGING GROUND MANAGEMENT

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Despite conservation measures, Florida's loggerhead nest counts have dropped by 40% in the past decade. This decline is reason for serious concern as approximately 80% of all nesting by the western Atlantic population of loggerhead turtles occurs in Florida. Management actions that would help reverse this decline need to be given high priority. While decreased nest numbers may be directly correlated with declining population sizes, this trend may also be a result of changes in the average length of the females' remigration intervals, with longer average intervals over time leading to an overall decrease in annual nest numbers. There are very few long-term tagging studies in the United States that have collected consistent data for remigration analysis and only a handful in the state of Florida. The Conservancy of Southwest Florida implemented a saturation flipper tagging effort on the southern 7.2 km of Keewaydin Island, off the southwest coast of Florida, in 1982. Since that time a total of 1,975 flipper tags have been applied to nesting females on Keewaydin Island with over 2,000 subsequent tag recoveries on the nesting beach during nesting events and nesting attempts, accounting for approximately 500 individual turtles. Flipper tagging data were used to characterize changes in the average remigration intervals for females nesting on Keewaydin over 27 years and were compared to fluctuations in annual nest counts for significant relationships. During the 2009 nesting season a satellite tagging component was also initiated to investigate post-nesting and foraging behavior. Satellite data were used to identify shared foraging grounds utilized by females between nesting years to link possible declines in their habitat quality to trends in remigration time, as degraded foraging habitats may lead to longer remigration intervals. Four nesting female loggerheads outfitted with satellite tags displayed fidelity to discrete foraging areas within one month of their final nesting event. Three of the four turtles remained on the continental shelf in the eastern Gulf of Mexico between 25˚ 40' N and 26˚ 20' N. The fourth female traveled over 500 km to the northern portion of the Great Bahama Bank, south of Andros Island, an area consistent with loggerhead tracks originating from other locations on the west coast of Florida. This particular turtle has the longest recorded nesting history on Keewaydin – first flipper tagged in 1988 and observed returning in 1991, 1997, 1999, 2001, 2003, 2005, 2007 and again in 2009. Some characteristics of the foraging areas include habitats near submarine springs or areas where bathymetry drops considerably. Specific management strategies based on preservation of foraging habitat quality are suggested to supplement current nesting beach protection.

THE CONSERVATION STATUS OF BIOKO ISLAND TURTLES IN EQUATORIAL GUINEA, AFRICA

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Four species of turtles are known to nest on the 19 km of black sand beaches along the southern shores of Bioko Island. For the past nine years (2000 to 2009) the Bioko Biodiversity Protection Program has employed local patrols to record turtle activity on these beaches. Total number of nests per nesting beach was recorded for all four turtle species. Leatherback nests were the most common, followed by green turtle, olive ridley and hawksbill nests. We observed a significant increase in number of olive ridley nests. However, there were no significant changes in the number of nests of other turtle species. There was a beach preference: leatherbacks seemed to nest more on the

southeast part of the island whereas green turtles preferred the southwest part of the island. Further studies are underway to discover the possible reasons for these preferences.

OLIVE RIDLEY SEA TURTLE NESTING IN THE COX'S BAZAR COAST, BANGLADESH

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Realizing the need to conserve and to protect sea turtles from declining populations, I have been giving attention to olive ridley sea turtle conservation since October 2007. Work takes place during the winter months of September to March with special emphasis on the critical stages of nesting, identifying exclusive nesting grounds and the release of hatchlings on the beaches of three Ecologically Critical Areas (ECA) namely Cox's Bazar-Teknaf Peninsula, Sonadia Island and Saint Martin's Island. A total of 65 nests were protected with the help of local people by using their own relinquished nets and wooden posts. A total of 10,075 hatchlings emerged from those nests between 2007 and April 2009. The main consumer of turtle eggs are indigenous people. Several awareness campaigns addressed to fishermen, school students and the community were run along the beach during the turtle nesting season. Out of 11 potential nesting beaches, six best suited sites were identified along the Cox's Bazar coast, namely Pechardwip, Sonadia west sand bar, Jahajpura, Hajampara, Badarmokam and Shilbaniar gola. These sites should be protected from human activities with suitable conservation strategies after taking fishing and other community members into confidence.

*SOCIAL DIMENSIONS OF MARINE PROTECTED AREAS

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This paper focuses on the legal framework for sea turtle protection in the Indian State of Orissa. It documents the social consequences of turtle protection measures on fishing communities and analyzes their experiences with various aspects of sea turtle protection. Its specific site focus is the Gahirmatha (Marine) Wildlife Sanctuary, and the areas of the Rushikulya river mouth and the Devi river mouth. Orissa's coastline of 480 km and continental shelf of 24,000 sq. km are spread across six coastal districts. The Gahirmatha (Marine) Wildlife Sanctuary, proposed in 1975 to protect the sea turtle nesting and breeding habitats, was finally designated in 1997. Orissa is the only State in India where turtle protection measures are undertaken within the framework of the Wild Life Protection Act (WLPA), 1972, and the Orissa State Marine Fishing Regulation Act (OMFRA), 1982, and Rules, 1983. The rise in the number of prohibitions and regulations has affected traditional and small-scale fishing operations and communities by reducing the actual area available for fishing, by cutting down the number of fishing days as well by curtailing access to fishing grounds. The social consequences — both direct and indirect — of the implementation of turtle protection measures on Orissa's fishing communities are many. They range from loss of livelihoods due to reduced access to fishing grounds, confiscation of vessels and arrest of crew to lengthy legal processes that undermine the socioeconomic status of fishers. It is not only active fishers who are directly affected by sanctuary regulations but also women who are actively involved in postharvest and marketing activities. Turtle conservation measures have thus alienated fishing communities, who feel targeted and excluded. In recent years, Orissa's fishing communities report higher levels of indebtedness, suicides and cases of mental illness. In view of the fact that there are still no clear indicators to show conclusively that Orissa's sea turtle population has indeed been restored or maintained, even after years of protection measures, these issues need to be urgently and sensitively addressed, in the interests of social justice and equity. This would also be in keeping with Section 26A of the WLPA, which highlights the need for measures to protect the occupational interests of local fishermen within sanctuaries, and the need to protect the right of innocent passage of any vessel or boat through the territorial waters. It is important to recognize the significance of conserving sea turtles, an important flagship species, and their habitat, within a wider coastal and marine management framework. It is equally important to take into account the social consequences of the implementation of conservation and management measures. Alternatives for the restoration and maintenance of turtle nesting populations, and the sustainable use of fisheries resources should attempt to go beyond an 'exclusionary protectionist mode' to an 'inclusive conservation mode'. In the long term, it is necessary to move

towards a comprehensive marine and coastal conservation and management policy framework, which will take into consideration India's international obligations under various conventions and regional instruments.

RESEARCH NEEDS IN SEA TURTLE CONSERVATION IN SRI LANKA

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In the past, sea turtle conservation activities in Sri Lanka were dominated by ex-situ conservation programs where sea turtle eggs were collected from the nesting beaches and reburied in a safe place away from the original nesting beach until they hatched. But since 1996 a few conservation projects have initiated some in-situ programs where turtle nests are protected at the nesting beach. This is more laborious and expensive work compared to ex-situ conservation. Safe entry of turtle hatchlings to the sea is the final goal of these hatchery activities. However, the sea turtles' conservation needs cannot be met only by releasing large numbers of hatchlings to the sea. Long-term studies on sea turtle nesting biology should be carried out in order to understand the turtles' conservation needs and promote their long-term survival. Proper understanding of their nesting behavior is essential to maintain ecologically effective hatchery management practices. A proper research program to monitor the nesting behavior of turtles has been conducted at Rekawa since 1996 and at Kosgoda since 2003. These activities should be continued and extended to other turtle nesting beaches in order to identify the nesting turtle populations in Sri Lanka. A research program was initiated in 2005 to study genetic diversity of green turtles nesting at Kosgoda rookery. During the project multiple paternity in green turtle hatchlings was also investigated. Monitoring the genetic diversity of adult turtles is a very important aspect of the turtle conservation program. Therefore, this study should be extended to the other turtle nesting beaches in Sri Lanka. The main problem faced by the turtle conservation programs in Sri Lanka is that monitoring and research is done only in a few locations due to the limitations of resources and trained personnel. Monitoring on the north and eastern coasts has not been carried out during the last 30 years due to terrorist activities in the area. However, with the defeat of terrorism, there are opportunities to extend turtle research activities to this part of the country.

COASTAL HABITAT PROTECTION AND ENFORCEMENT OF REGULATIONS – A PRIORITY FOR SEA TURTLE CONSERVATION IN BANGLADESH

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Increases in the magnitude of land-based activities, conversion and alteration of coastal land, disturbances, unregulated tourism and artisanal fishing are some of the concerns that need to be tackled by the Government of Bangladesh to conserve nesting sea turtles. The major nesting beaches of St. Martin's Island and Teknaf Peninsula – though they were declared as protected areas under the Bangladesh Environmental Conservation Act of 1995 – still need high-level government and political interventions to be managed effectively. Beaches of tens of off-shore islands still need to be explored as potential sea turtle nesting habitats. Seasonal fishing in the bay, particularly during the winter, coincides with the higher frequency of nesting sea turtles and most of the mortalities occur during that time. Nesting beaches located within the Sunderbans Reserve Forest are mostly disturbed by seasonal fishing villages. Physical changes in the landscape and beach sand dunes are affecting turtle nesting sites and also putting female turtles under immense stress in nest site selection. Moreover the reduction in the numbers of nesting females is also a cause of concern that suggests the need to address issues beyond the beaches. It is high time that policies give concrete guidelines and identify niches within the legally protected beaches for 'zero-tolerance' with full-fledged no disturbance labels. The paper discusses issues of tourism regulation, regulating land-based activities and recommendations from the Coastal Development Strategy, National Biodiversity Strategy and Action Plan for the conservation of sea turtles in Bangladesh. Emerging issues like the impact of climate change on the sea turtle nesting habitat is also discussed.

EVALUATION OF CONSERVATION MEASURES FOR HAWKSBILLS (*ERETMOCHELYS IMBRICATA*) NESTING IN THE DOMINICAN REPUBLIC

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Here we present the first study conducted in the most important nesting site for the hawksbill sea turtle (*Eretmochelys imbricata*) in the Dominican Republic, Saona Island (Este National Park, Southeast DR, 18º07'N 68º44'W). Its conservation status, population threats and conservation measures currently implemented are evaluated. The greatest threat to this nesting population is the illegal take of eggs and of adults for their meat and shell. In 2007 a program for relocation and artificial incubation of nests in plastic coolers was initiated. To assess the effectiveness of this conservation strategy, hatchling production in plastic coolers in 2007 and 2008 was compared against the theoretically estimated production for each year in the presence and absence of human predation of naturally incubated clutches. We estimated that artificial incubation increased hatchling production by 16% in 2007 and by 44% in 2008 in relation to the production estimated in presence of human predation and no conservation measures taken. Possible negative effects of artificial incubation were evaluated through (1) comparisons of emergence success between naturally incubated (on the beach) vs. plastic cooler incubated clutches and (2) biometric measurements between the resulting hatchlings from Saona against those of other populations in the region. No differences were found in terms of emergence success between the two incubation methods. On average, hatchlings produced in coolers in Saona exhibited body size and mass measurements slightly below those of other populations from the Caribbean and other regions. However, comparisons with naturally incubated hatchlings from the same location are needed to ascertain whether these differences are due to intra-population characteristics or to incubation conditions. We concluded that, with proper handling techniques, movement of eggs for their incubation in plastic coolers is an effective measure to increase hatchling recruitment to the sea. Nonetheless, more studies are in progress to determine any negative effect this conservation strategy may have, such changing the temperature regime of nests, which could lead to a biased sex ratio in the emerging hatchlings.

*ROLE OF THE GULF OF MANNAR BIOSPHERE RESERVE TRUST IN THE CONSERVATION OF MARINE TURTLES

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Although sea turtle nesting has not been reported in the 21 islands of Gulf of Mannar or in the Gulf of Mannar Biosphere Reserve region in recent times, turtles inhabit the region because this ecosystem is considered to be a good feeding ground. The fishing communities of the Gulf of Mannar were the main threat to the population in this region. The Gulf of Mannar harbours four species of sea turtle (*Lepidochelys olivacea*, *Chelonia mydas*, *Eretmochelys imbricata* and *Dermochelys coriacea*). Up to 2001, captures in the region involved mostly green turtles. Since then, green turtle capture numbers and sizes have both decreased dramatically while olive ridley captures have increased. The incidental captures of these turtles occurred with fishing gear such as shore seines, bottom trawl nets and gill nets. To conserve sea turtles, GOMBRT has been running awareness programmes in its 252 project villages. To increase awareness in the fishing community GOMBRT has created a Village Marine Conservation and Eco Development Committee aiming to conserve the Schedule species which have been listed under the Wildlife Protection Act, 1972. In addition, GOMBRT with the active support of the Forest Department and other line departments has been undertaking joint patrolling and monitoring of captures offshore and has established the Anti Poaching Watchers to monitor the captures of schedule organisms such as turtles.

ARTIFICIAL LIGHTING EFFECTS ON *CARETTA CARETTA* HATCHLINGS IN SAL, CAPE VERDE (AFRICA)

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One of the most densely populated nesting grounds of *Caretta caretta* on the island of Sal in Cape Verde is a stretch of beach known as Algodoiero and Paradise Beach. Recent development around this area has been the main cause of hatchling mortality. Due to the bright lights left on by developers, many hatchlings emerge and move straight towards the artificially lit horizon created by the construction site. In 2008, 100% of nests left in-situ on Algodoiero and more than 30% of nests in Paradise Beach had problems due to artificial lighting. In 2009, we aimed for a reduction in hatchling mortality by working with developers to have their lights switched off or to simply use turtle safe lighting. After many unsuccessful attempts in 2008, developers were persuaded that their lights were causing a major impact on the survival rate of hatchlings. The developer's attitudes have changed dramatically this year. If lights were not turned off, they were angled so that they were facing away from the ocean. So far this season, only around 27% of nests on Algodoiero have had problems with artificial lighting (down 73%) and about 13.5% on Paradise Beach (down 16.5%). Translocation to the hatchery was another option early on when lights were not fixed. From the hatchery, more than 8,800 hatchlings have been released that might otherwise have been affected by artificial light. Artificial lighting from developments was also a problem on Surf Beach. In 2008, 100% of nests laid there had problems with artificial lighting. By informing the public and raising awareness, by word of mouth as well as distributing leaflets, we were able to persuade many people to allow us to filter their lights. The filters were created using recycled bottles which were spray painted red with oil based paint and fit to the lighting fixtures of their houses. This dramatically dimmed the artificially lit horizon created by the brightly lit developments. As a precaution, a second method was employed; three sided fences were placed around each nest, with the opening facing toward the sea. Unfortunately this season, there was a problem with one beachfront bar owner who has refused to turn off his lights. This has contributed to only around one third of the nests laid on this beach making it to the sea. There still needs to be a change in the entire communities' attitudes toward sea turtles. Eliminating all lighting by coastal development during nesting season is one possible solution. However, this is not feasible on many of the beaches in Sal, so alternate solutions must be brought to the attention of many developers, such as implementing and enforcing regulations which require developers to install turtle safe lighting. As well as working with developers, we continue to educate and inform the public about the artificial lighting problem in Cape Verde, but only larger scale cooperation and involvement by the community will ensure the existence of the loggerhead sea turtle on the island of Sal.

CONSERVATION OF MARINE TURTLES IN SOME COASTAL AREAS OF BANGLADESH AND IMPLICATIONS FOR THE DEVELOPMENT OF A NATIONAL POLICY REGIME

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At least five species of marine turtles are known to visit the Bangladesh coast for nesting. The Teknaf peninsula, Sonadia and St. Martin's islands are the major destinations for a huge number of individuals of these nesting species. The Coastal and Wetland Biodiversity Management Project (CWBMP) has been working in these areas for the conservation and management of globally significant species. Turtle conservation has been an important and priority intervention of the project. The major threats to the nesting turtle population are: entanglement of turtles in fishing nets, predation of eggs by dogs and jackals and collection of eggs by local people for sale and household consumption. A number of project interventions targeting the conservation of turtles have been taken, including ex-situ and in-situ conservation of eggs, dialogue with fishermen for the safe release of turtles caught in fishing nets, killing of stray dogs in the beaches, and raising of awareness among the local community. During the last three years, a total of 66,000 eggs were transferred to hatcheries and produced 57,000 hatchlings for release into the sea.

As an alternate option to ex-situ hatching of eggs, 12 turtle nests were also protected in-situ by fencing and had successful release of the hatchlings into the sea. A number of meetings were also held with the fisher community and demonstrated safe release of turtles entangled in nets. Considering the sustainability issue of the turtle conservation program, engagement of local community organizations in the conservation process is being explored. The constraints and issues regarding non-compliance to the use of TEDs in fishing nets are also being identified. The implications for developing a national policy for the conservation of the marine turtles are discussed.

PREDICTED SEA LEVEL RISE IMPACTS ON THE SEA TURTLE NESTING BEACHES OF LOS CABOS, MEXICO

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Baja California Sur, México represents the northern-most region where olive ridley turtles (*Lepidochelys olivacea*) nest in the Pacific, and it also supports important nesting grounds for Pacific leatherbacks (*Dermochelys coriacea*). Short-term threats such as beach development and construction of marinas combined with long-term threats such as sea level rise could contribute to a decline or elimination of suitable nesting habitat for sea turtles. The objective of this study was to assess future threats to nesting beaches from sea level rise by profiling twelve beaches over a thirty-two kilometer stretch in the San José del Cabo, Baja California Sur area. Two university students enrolled in The Science Exchange internship program worked with technicians from the Municipal Sea Turtle Conservation Program of Cabo San Lucas for six weeks during the summer of 2008. We collected distance and slope data for the tracks of nesting turtles from the waterline to the nest with a tape measure and an inclinometer. At the same time we collected sand grain samples at the nest which were categorized visually by size into 7 classes (superfine to rocks). The sample included 55 olive ridley nests and one black turtle (*Chelonia mydas agassizii*) nest. The average distance from waterline to nest was 27.1 meters, the mean slope from waterline to nest was 6.7 degrees, and the mean elevation of nests was 2.3 meters above sea level. Turtles nested in all sand grain sizes, preferring medium grains. La Fortuna beach supported the most nesting during the study period, followed by Zacatón and Hotelera (a highly developed resort beach). In Excel we modeled a predicted sea level rise of 0.6 m over the next 100 years assuming the same topography found in August 2008. In the modeled scenario, eight nests, or 14% of the total found during the study period, would be at risk of inundation if they were left in situ. Variables such as changing currents, erosion and accretion, and adaptation of sea turtle nesting behavior were not considered. The results support the need for continued monitoring of the slope and beach width every few years. Conservation recommendations to protect Baja California Sur's important nesting beaches from sea level rise include continued translocation of nests (the main purpose of which now is protection from poachers and predators), proactive zoning and limitation of development along the coast, and stricter enforcement of no-development in the protected "federal zone" (20 m from mean high tide).

CONSERVATION OF SEA TURTLES AT THE PALMYRA ATOLL NATIONAL WILDLIFE REFUGE, CENTRAL PACIFIC

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Little is known about the demographic characteristics, distribution, and population status of globally endangered sea turtles in the Central Pacific at the remote and sparsely inhabited Palmyra Atoll National Wildlife Refuge (PANWR). This lack of knowledge hinders comprehensive management and conservation efforts at a site that may

represent a key foraging area for sea turtles. We therefore initiated a conservation research program on sea turtles at the PANWR in 2005. Our work to date has revealed that green turtles (*Chelonia mydas*) are the most common species at this feeding ground, while hawksbill turtles (*Eretmochelys imbricata*) appear to be relatively rare. Here we present data focusing on the morphological characteristics of green turtles in waters of the PANWR. A total of 90 green turtles were captured during field seasons in 2008 (n=41) and 2009 (n=49), with no recaptures between seasons. Study animals measured from 47 to 114 cm curved carapace length (CCL) and weighed between 10.2 and 146.3 kg. These turtles appear to range from relatively small post-pelagic juveniles to large adults of likely breeding age. We assessed their size distribution in 10 cm CCL intervals, and found that the highest frequencies of turtles fell within the 61–70 cm interval (n=90). We divided the atoll into four geographical regions. Turtles captured in one area, the East Lagoon/East Flats, were significantly smaller for all measurements (weight, curved and straight carapace lengths and widths) than those in the other three regions ($F=5.53$, $df=3$, $p=0.002$), perhaps indicating some stage-specific preferences in habitat utilization. Although generally very healthy, turtles showed a variety of healed injuries including carapace damage indicating predator attack (n=5) and severely damaged (n=27 turtles) or missing flippers (n=7 turtles). The density of potential shark predators at this small atoll inhabited only by a few researchers and management personnel is one of the highest in the world, and may be a major factor in sea turtle behavior and population density there. Other potential threats to sea turtles at or near PANWR include longline fisheries and toxins from military residue at the atoll. Results from this study will contribute to the development of a management plan and to the effective management of sea turtles and their ecosystems at the Wildlife Refuge, advancing federal recovery objectives, as well as to a better understanding of sea turtles in the greater Pacific region.

RECENT CHANGES OF HAWKSBILL (*ERETMOCHELYS IMBRICATA*) NESTING STATUS IN THE JAVA SEA, INDONESIA

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Indonesia was the biggest export country of hawksbill shell, Bekko, in the world. Bekko harvested in Indonesia was exported to Japan until 1986, especially in 1973 and 1979 when the equivalent of about 20,000 hawksbills was exported. The impact of egg collection still remains in some rookeries because of an increase in human population and economic value of turtle eggs. Egg collection in the Java Sea was expanded rapidly when a large number of bugis people (maritime people originally from South Sulawesi) moved into this region in the early of 1970s. A large-scale egg collection under the bid systems by local governments still is confirmed in some rookeries. In case of Tambelan Islands (Riau Province), although the local government stopped the bid system for egg collection in 2008, local people keep collecting eggs illegally. At present, egg collection in the Java Sea has a great impact for the Indonesian hawksbill population which is decreased by the impact of Bekko harvest. Nesting beach surveys of 15 hawksbill rookeries have been conducted since 1990 with protecting eggs and monitoring nesting status in three rookeries (Segama, Momperang, Kimar). To assess the hawksbill nesting status in the Java Sea, the number of body pits in seven surveyed rookeries (Gresik, South Natuna, Tambelan, Bintang, Lingga, Singkep, Sambergelap) and the number of nests in three protected rookeries during the past 10–15 years was analyzed. A slight decrease in the number of body pits was confirmed in six of seven surveyed rookeries (Gresik; from 231 body pits in 1996 to 203 in 2008, South Natuna; from 318 in 1999 to 285 in 2009, Tambelan; from 125 in 1998 to 106 in 2009, Bintang; from 151 in 2003 to 192 in 2009, Linnga; from 104 in 2003 to 94 in 2009, Singkep; from 57 in 2003 to 27 in 2009, Sambergelap; from 774 in 2006 to 672 in 2009). On the other hand, a great increase in the number of nests was confirmed in two of the three protected rookeries (Segama; from 182 nests in 1999 to 469 in 2008, Momperang; from 278 in 2001 to 480 in 2008, Kimar; from 341 in 1999 to 189 in 2008). A serious decline (about 72%) in Indonesian hawksbill nesting activity was documented in the 1980s, but nesting status in the Java Sea during the past decade has been stable with an increasing nesting trend in a few protected rookeries.

CUBA-US-MEXICO WORKING GROUP IN MARINE SCIENCE AND CONSERVATION

Fernando Bretos Trelles

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The Tri-National Working Group for Marine Science and Conservation for the Gulf of Mexico is a new framework for collaborative Cuba-Mexico-U.S. research and conservation activities. Six key priority areas were identified and discussed at a preliminary meeting in Cancun, Mexico in 2007: research and conservation of coral reefs, research and conservation of sharks, research and conservation of sea turtles, research and conservation of dolphins, research, conservation and management of fish resources and strengthening of marine protected areas. Working groups, headed by one representative from each of the three countries, have worked together at two meetings since (Veracruz 2009 and Havana 2009) to establish research priorities that will constitute a Plan of Action which will be launched in early 2010. Recognizing the critical need for more scientific research in the Gulf of Mexico and Western Caribbean, this effort is bringing together major institutions and governments from both countries to establish research priorities and chart a way forward toward stronger and more comprehensive collaborative activities, including continued research on the five species of sea turtle that inhabit the region.

CUBAN/MEXICAN FISHER'S EXCHANGE AT ISLA DE LA JUVENTUD, CUBA

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A fishers' exchange between Cuban and Mexican fishers representing the Grupo Tortuguero took place from April 22–30, 2009 on Cuba's Isla de la Juventud (Isle of Youth). A group of 28 fishers, marine scientists and fisheries managers from Cuba, Mexico and the U.S. gathered at Siguanea Bay off the island's remote southwest coast. This unique informational exchange between Cuba, the Yucatan and Baja California peninsulas is part of the Sea Turtle Working Group – an unprecedented tri-national research and conservation group led by The Ocean Foundation to study and conserve shared marine resources by the three nations of the Gulf of Mexico. The goals of the exchange were to provide a forum for sea turtle experts and communities in the three bordering countries (Cuba, Mexico, USA) to exchange experiences on conservation activities, expand livelihoods for Cuban fishers and develop the scientific basis for future conservation in this highly productive region of Cuba. Fishers' exchanges have proven effective in implementing effective conservation schemes and gathering pertinent data, particularly in more isolated, small-scale fisheries where management is limited. Through these exchanges, fishers facing similar biological and political challenges exchange ideas and perspectives that can help in reducing turtle bycatch (Peckham and Maldonado-Diaz, 2009). The fisher's exchange took place over four days in the Bay of Siguanea and Punta Frances, a nature reserve on the southwest corner of the island. Fishers representing GT and fishers and conservationists from the Mexican states of Yucatan, Campeche and Quintana Roo boarded Cuban lobster and bonito fishing vessels to informally exchange information. This included discussions about the types of fishing implemented in these waters, the likelihood of bycatch and the general feelings and attitudes Cuban fishers have for sea turtles.

FIELD EXPERIMENT TO ASSESS LOGGERHEAD HATCHLING ORIENTATION DISRUPTION BY ARTIFICIAL LIGHT OF DIFFERENT WAVELENGTHS

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Ambient light is a primary cue for sea finding orientation by newly hatched sea turtles. Artificial light sources can alter ambient light patterns and disrupt hatchling orientation to the sea. Southern Kyparissia Bay, Greece, is an important nesting area for the loggerhead sea turtle (*Caretta caretta*) in the Mediterranean, and has been monitored since 1984 by ARCHELON. The Bay is mostly backed by sand dunes, forest, and farmland. One part of the site is

backed by the town of Kalo Nero, where hotels, tavernas, and bars illuminate the beach without restriction. In a significant proportion of the nests in that sector of the beach, this disrupts sea finding of hatchlings, contributing to hatchling mortality. In order to mitigate the problem, ARCHELON volunteers use boxes to trap hatchlings as they emerge from their nests and move them to a dark location on the beach, where they are able to safely crawl to the sea. We conducted a series of experiments in the summer of 2009 in order to assess the disruption of sea-finding orientation caused by artificial light of different wavelengths and intensities. We released hatchlings, selected from boxed nests, in a circular horizontal arena which had been constructed on a dark location on the beach. Arrays of monochromatic LEDs were used to shine artificial light of controlled colour and intensity on the arena from a right angle to the direction of the sea. The colours used were UV, violet, blue, cyan, and orange. Three intensities were selected after initial trials and these were used in equal photon flux for all wavelengths. The average orientation angle in each treatment from that when no lights were used was considered as the deflection angle. Moon size and direction were also recorded. In the absence of artificial lights, hatchlings oriented towards the shortest path to the sea. When they were exposed to artificial light, their orientation deflected from that direction to the side where the lights were located. The deflection angle increased with light intensity. When orange lights were used, the deflection angle was smaller. In the presence of moonlight, the deflection angle was reduced increasingly with moon size in all colours. This study confirms previous research on hatchling orientation disruption caused by artificial lights. Although shorter wavelengths have a greater impact, orange lights can also cause problems and should not be ignored by relevant studies and assessments. Further research is required to increase the available data and to use these findings to establish an economically viable method for the predictive assessment of existing artificial lights on sea turtle nesting beaches.

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*OSTIONAL ARRIBADAS: IS EGG HARVEST AN EFFECTIVE CONSERVATION/MANAGEMENT STRATEGY?

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Olive ridleys nest en masse at Ostional beach, Costa Rica. Arribada nesting at this beach dates from at least the mid 1950s. Arribada events are known to include tens of thousands of female turtles and last for several days. These events have been documented to occur approximately once a month, with some months supporting none (dry months) or two (rainy months) arribadas. Interestingly, arribada nesting seems to focus on a small section of beach, which results in a high nest density. Early studies on the nesting ecology of these turtles conducted since the early 1970s indicated that a large proportion of eggs oviposited early in the arribada exhibit a significant likelihood to be destroyed by later egg-laying females; in addition, it was also seen that hatchling production at this beach was significantly lower relative to nests from solitary nesting turtles. High embryo mortality rates have been attributed to density-dependent effects. Large destruction rate of early eggs (doomed eggs) became the basis for a community-based egg harvest established in the mid 1980s. This harvest program was not only seen as a way to decrease the perceived waste while providing a source of income to the community but also as a mechanism to decrease nest density, in an effort to diminish density-dependent mortality of ridley embryos. This paper will focus on discussing the population trend at Ostional beach including the period in which the egg harvest program was initiated. Using our strip transect in time to estimate arribada abundance empirical data from our now four year old project along with historical arribada records we will discuss the standing of the Ostional population. In addition, we will examine the importance of the egg harvest in relation to its effectiveness (or lack thereof) as a mechanism to reduce density-dependent effects on embryo development.

FOUR YEARS OF MARINE TURTLE PROTECTION (2005/2009) IN OAXACA COAST, MEXICO

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"Red de los Humedales de la Costa de Oaxaca" is a community-based conservation network devoted to protecting the coastal natural resources of interest to its members. The network's sea turtle program, PROTUMAR, coordinates sea turtle conservation work in five communities. Since 2005, nest protection efforts have been executed for three species of turtle, *Lepidochelys olivacea*, *Chelonia mydas agassizii* and *Dermochelys coriacea*, producing thousands of hatchlings that have been released into the ocean each year. For the olive ridley sea turtle, on the beach of "La Ventanilla", 1,003 nests have been protected, 95,778 eggs have been incubated and a total of 59,997 hatchlings have been released with an 85.5% protection success rate. In the "El Tomatal" campsite, 1,110 nests have been protected, 96,997 eggs incubated and 52,737 hatchlings released (81% protection success rate). For the "Los Naranjos" campsite, which has operated for only three seasons, 553 nests have been protected, 53,698 eggs have been incubated, and 19,512 hatchlings have been released (92% protection success rate). For the "Cerro Hermoso" campsite, 249 nests have been collected, with 20,633 eggs incubated, and 13,934 hatchlings produced and released (54% protection success rate). Finally for "La Tuza de Monroy" campsite, an important nesting beach considered to be a leatherback secondary beach, 965 olive ridley nests have been protected, 85,470 eggs have been incubated, and 6,795 hatchings released (71% protection success rate). For the leatherback turtle, the campsites that have the largest number of protected nests were "La Ventanilla" with a total of 45 nests (98% protection success rate) and "El Tomatal" with 19 nests (86% protection success rate); for the Black sea turtle, "La Ventanilla" registered 28 nests and produced 1,239 hatchlings (100% protection success rate). The work accomplished is of great importance as it is a communal initiative of people concerned over the disappearance of their natural resources. The number of protected turtle nests and released hatchlings is an important achievement for the coast of Oaxaca population, but most of all it shows a deep level of awareness in local people. Traditionally, people living in the area used to consume turtle eggs. Protection is necessary to increase sea turtle populations and will also permit educating and always adding more people to help the marine turtles in Mexico.

A RETROSPECTIVE ANALYSIS OF SEA TURTLE NEST DEPREDATION PATTERNS AT CANAVERAL NATIONAL SEASHORE, FLORIDA

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Nest predation can significantly reduce hatchling recruitment in sea turtle populations. Understanding predation patterns spatially and temporally aids our understanding of nest risk and enhances management strategies on nesting beaches. This study compares predation patterns of loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtle nests at Canaveral National Seashore, Florida, USA, over a 20-year period (1989–2008). Nest predation by small mammals (mostly raccoons, *Procyon lotor*), and invertebrates (mostly crabs, *Ocypoda quadrata*) is common (8–45% per year). This study aims to (1) identify if a predation event on a particular nest affects later predations on the same nest, (2) understand the influence of varying levels of human beach use (limited, moderate, and heavy) on nest predation frequency and (3) spatially and temporally quantify individual nest predation risk. Chi-square tests were used to determine if secondary predation events were related to the nest's primary depredation event. Primary predation increases the chance of a nest suffering subsequent predation ($\chi 2=755$, df=8, $p<0.0001$) even when that nest is reburied and protected by screening. This indicates physical and/or chemical cues left by primary depredation are likely to alert secondary predators. To determine if human beach use and frequency of nest predation are spatially or temporally linked, we divided the beach into grids, ranked human beach use (defined by beach access use) and examined predation frequency across all marked nests (n=40,423). Primary and multiple predation events

occurred with greater frequency in limited areas (primary, n=84/grid; multiple, n=13/grid). Primary predation was lowest in moderate-use areas (n=36/grid). Nests in heavy-use areas experienced a relatively high, yet intermediate frequency of primary predation (n=62/grid). Multiple predation frequency (n=6/grid) was the same in high- and moderate-use areas. The high primary predation frequency in the limited-use areas may approximate natural levels because anthropogenic disturbances (e.g., supplementary food, human acclimation or interruption) are lower in these areas. Heavy-use areas, which suffered intermediate predation frequency had the greatest number of corridors (boardwalks, roads, less dense vegetation), suggesting predators could move more freely to and from the beach than at limited-use sites, but may be disturbed more frequently during predation. The low frequency of predation in moderate-use areas may reflect combined effects of alternate food sources (trash and eggs) available to predators and somewhat more restricted access between environments. Survival analysis showed nest predation risk decreased by 29.5% over the study period, suggesting that mitigation helped and/or predator densities declined over time. Nests deposited in the middle of nesting season were 9.8% more likely to be predated than nests deposited early or late. Compared to nests in limited-use areas, those in moderate-use and heavy-use areas, respectively, had 17.7% and 11% less risk than nests in limited-use areas. Heavy- and limited-use areas had similar nest abundances, yet predation risks were lower suggesting that anthropogenic disturbances may reduce predation risk. These results support management options that focus anti-predator strategies in limited-use areas at this rookery, particularly in the middle of nesting season.

COMMUNITY-CENTERED TAKE REDUCTION OF SEA TURTLES AND MONK SEALS IN THE NEARSHORE FISHERIES OF THE MAIN HAWAIIAN ISLANDS

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The State of Hawai`i is rich in both marine wildlife and cultural traditions surrounding the ocean. Endangered and threatened species occurring in nearshore Hawaiian waters include the green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*) and Hawaiian monk seal (*Monachus schauinslandi*). The Hawai`i State Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) has initiated a new program dedicated to managing and resolving areas of conflict between Hawai`i's ocean users and its natural resources. The DLNR Marine Protected Species (MPS) program has evolved from various on-going efforts within DLNR and supports the conservation and recovery of sea turtles and monk seals as well as the preservation of traditional fishing culture in the Main Hawaiian Islands (MHI). We plan to achieve these objectives by enhancing state agency and local community participation in management, monitoring, research, and outreach activities. Primary goals of the MPS program include: 1) developing fishing gear and bait modifications designed to reduce incidental take of protected species, 2) developing and distributing public education products and activities designed to enhance knowledge among fishers of "turtle-friendly" and "seal-friendly" fishing practices, 3) examining existing and potential new State regulatory measures (i.e. gear requirements, gear restrictions, and area closures) designed to reduce incidental take and to enhance conservation and recovery, and 4) developing methods of monitoring and reporting sea turtle and monk seal interactions in State-managed fisheries. The MWP will continue on-going efforts to test, refine, and disseminate community-based marine protected species conservation methods for use throughout Hawai'i. To date, completed program activities include over 600 shoreline intercepts with fishermen resulting in prevention or documentation of interactions between recreational fishers and protected species as well as outreach opportunities, more than 60 responses to hooked or entangled turtles or seals, and attendance at 20 shoreline fishing tournaments to distribute barbless circle hooks and outreach materials in collaboration with NOAA Pacific Islands Fisheries Science Center (PIFSC). Long-term program goals include: 1) continuing outreach to reduce interactions between humans and sea turtles and Hawaiian monk seals with a focus on recreational fisheries, 2) improving survival of injured, hooked, or entangled ESA-listed marine species, 3) enhancing community support and participation in sea turtle and marine mammal conservation, and 4) collecting and evaluating technical information required for enhanced endangered and threatened marine species conservation provided to NOAA Fisheries Service, the State of Hawaii, and all concerned parties.

*ASSESSING THE POTENTIAL RISK TO MARINE TURTLES FROM INDUSTRIAL FISHERIES IN THE COASTAL WATERS OF GABON

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Gabon hosts the world's largest rookery of leatherback turtles (*Dermochelys coriacea*) and deleterious fisheries interactions are known to occur. A better understanding of the potential risks posed by industrial fisheries is therefore essential to inform mitigation of fisheries bycatch. We describe the habitat use of leatherback turtles during internesting periods, gained from satellite tracking over four seasons (n=21 individuals, n=36 internesting periods). Data suggest that leatherback turtles distribute widely during the internesting period, although in a somewhat predictable manner in a long-shore direction from nesting locations. Using a modelled internesting footprint integrated with spatio-temporal pattern of nesting, gathered from aerial surveying of the Gabon coastline collected over three seasons, we estimate at-sea densities of leatherback turtles. We propose that the resulting spatially explicit data product on leatherback turtle distribution should be integrated with data on the distribution of industrial trawlers, as made available by the Vessel Monitoring System (VMS) operated by the Gabonese Government. The resultant analysis will help inform the development of appropriate mitigation strategies.

ITSAS DORTOKA PROJECT

Nagore Zaldua-Mendizabal, Manu Océn-Ratón, and Aitziber Egaña-Callejo

Aranzadi Society of Sciences

The Itsas Dortoka Project (IDP) involves a work team in the Observatory of Herpetology of the Aranzadi Society of Sciences Centre which is dedicated to the study, conservation and popularization of sea turtles. It was set up in 2007 and it has since focused its efforts toward collaborating with different organizations; committing to working closer together and to developing future priority initiatives which will improve knowledge and contribute to marine turtle conservation in the area. This way different shared initiatives have been achieved. The lack of knowledge on sea turtles in the Bay of Biscay and the need for joining forces to achieve a database that would provide for future ecological studies were the initial reasons why we undertook this project. The Observatory of Herpetology, acknowledging the need for a specialist group on these reptiles, led the establishment of the work team. The lack of knowledge of their presence and situation in these latitudes contributed significantly to the creation of the group. IDP´s activities include the implementation of the "Preliminary approach to study the presence of sea turtles in the Basque Country waters" project in 2007–2008, participation in the "Basic course on the identification of the reptiles of the Basque Country" in 2008, the organization of the "First Workshop on Sea Turtles in the Bay of Biscay and the North East Atlantic" held in San Sebastian in 2008, the establishment of the environmental volunteers program on sea turtles in Cape Verde in 2008–2009, the rehabilitation and study of Casiopea, an injured loggerhead released back into the sea in Santurtzi (Biscay) during 2009, and the 2009 evaluation of *Caretta caretta* and *Dermochelys coriacea* for their incorporation into the Red List of Threatened Species in the Basque Country. Future activities for 2010 include the implementation of a study on "The evaluation of sea turtle bycatch by the Basque fleet in the Bay of Biscay and the North East Atlantic" and the organization of a sea turtle exhibition at the Donostia-San Sebastian Aquarium.

STATUS OF SEA TURTLES IN THE MALDIVES

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Historical writings have documented nesting of five species of marine turtle in the Maldives. However, there is little to substantiate this in the context of available literature and local observations and reports for the past 30+ years. This study focuses on the distribution and abundance of the most common two species, the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*), and their distribution, abundance and nesting seasonality based on available egg harvesting data. Distribution and abundance of less common species are also discussed. Management and conservation oriented efforts have been implemented since as early as the 1970s with a recently imposed 10 year ban on killing of all species of sea turtles in the Maldivian waters until 2016. A nationwide egg harvesting ban has been effective since 2007. The impact of these bans on the nesting populations and management and enforcement challenges associated with these bans are discussed.

ECOSYSTEM FUNCTION

*GREEN TURTLE HERBIVORY IN SEAGRASS MEADOWS: ARE WE DEALING WITH AN ECOSYSTEM MODIFIER?

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Ecosystem modifiers have the ability to significantly alter the ecosystems they inhabit by directly affecting the structural elements of their habitats. We have inherited the concept of the ecosystem engineer from terrestrial ecosystems where it has been applied to organisms as diverse as elephants and termites. Here we evaluate if marine herbivores, and in particular green turtles (*Chelonia mydas*), can function as significant ecosystem modifiers, and what the consequences of their herbivory is on the habitats they feed on. We present a case study that was conducted in a seagrass-dominated lagoon in the Lakshadweep Islands, Indian Ocean, where a stable high-density congregation of green turtles is resident. We evaluate the effects that turtle herbivory has on seagrass ecosystem structure and function. We use a naturally occurring gradient in green turtle herbivory to document changes in seagrass structure as measured by species composition, flowering, shoot length and width, and shoot density. Seagrass function is measured in terms of plant turnover-rate, plant growth and refuge availability (canopy height). We discuss the implications of these results in the context of the role that other seagrass herbivores perform and the potential role of ecosystem modifiers in marine ecosystems now and in the past.

GREEN TURTLES AS MULTISPECIFIC SEAGRASS MEADOW'S ENGINEERS

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In the present context of global change with biodiversity erosion, our understanding of the ecological processes through which ecosystems structure and function is both crucial and pressing. Among large marine herbivores, green turtles, *Chelonia mydas,* constitute a significant part of the consuming biomass, and a key structuring component of shallow coastal seagrass ecosystems. Indeed, previous grazing simulations report that green turtles improve the productivity and nutritional composition of the seagrass meadows they exploit. By extension, one may predict that the absence of grazing green turtles may produce lower quality seagrass, with potential consequences for ecosystem functioning. The southwestern Indian Ocean hosts globally important multispecific seagrass meadows and Comoros Archipelago is amongst the prime biodiversity hotspots. To predict trends associated with current global change, we tested the above-mentioned prediction by assessing the effects of the simulated absence of green turtles on the seagrass successional process of a tropical multispecific seagrass meadow at Mayotte Island (12°58'S, 45°05'E). Our study was conducted in the bay of N'Gouja, where green turtles feed year-round and represent the only significant seagrass herbivore in the area. The absence of green turtles was simulated during 256 ± 48 days (from 45 to 400 days) using eight exclosures (1 x 1 x 0.5 m) made of 5-cm wide mesh wire, which prevented intrusions by green turtles but also other large, yet rare, species (hawksbill turtles, stingrays and eagle rays) and fish, without altering light, water flow conditions and entrance of small vertebrates and invertebrates species. Exclosures were equally set in the two main seagrass communities of the meadow, called C2 and C3. C2 corresponded to a *Halodule uninervis* dominated community, where *Halophila ovalis*, *Cymodocea rotundata* and *C. serrulata* also occurred, whereas C3 was a *H. uninervis*- and *Syringodium isoetifolium* dominated community, where *H. ovalis*, *C. rotundata*,

C. serrulata, and *Thalassia hemprichii* also occurred. Concurrent monitoring of the meadow indicated that during the entire experiment, seagrass composition did not change outside the exclosures. Within the exclosures however, 44.5 ± 5.6% and 41.7 ± 10.1% of initial seagrass species disappeared within 320 days, in C2 (n = 2 exclosures) and C3 (n = 3 exclosures), respectively, and slow-colonising seagrass species progressively replaced pioneers. In the richest seagrass community (C3), the total number of seagrass species decreased by 40.0 ± 0.6% within 310 days (n = 4 exclosures). In absence of green turtles, the decline of nitrogen-rich, pioneer species abundance may cause a poorer-quality foraging habitat, and the reduction of species diversity may result in loss of associated faunal assemblages. This study shows that green turtles limit seagrass succession and maintain an intermediate successional stage, thus playing a key role in managing marine coastal biodiversity by acting as ecosystem allogenic engineers. This provides further arguments for developing integrated efficient management policies and conservation strategies for endangered sea turtles and their habitats.

*DOES TIGER SHARK PREDATION REALLY AFFECT GREEN SEA TURTLE ECOSYSTEM DYNAMICS?

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Understanding the ecological role of marine turtles requires an ecosystem-based modeling approach. Quantitative approaches such as simulation models are the preferred choice but this approach requires extensive knowledge of complex ecological processes that are poorly known for most marine species, including marine turtles. Qualitative modeling approaches such as graph theory (signed directed graphs and matrix algebra) are a promising new way to address the challenging questions relating to unraveling the ecological role of marine turtles. I demonstrate the utility of this approach by evaluating the ecosystem dynamics of the green turtle-seagrass-macroalgal community in Shark Bay (Western Australia). The community or food web matrix underlying this model comprises nine states and the direct and indirect interactions between these states: primary producers (seagrass, macroalgae), major consumers (dugongs, green turtles, sea urchins, herbivorous fishes), major predators (tiger sharks, carnivorous fishes) and a detritus pool. I then use a perturbation approach with both density-dependent and independent versions of this model to assess whether tiger shark predation affects the long-term dynamics of this community structure. It was apparent that tiger shark predation has a far greater effect on dugong and consequently seagrass population dynamics rather than the Shark Bay green turtle population. This robust qualitative modelling approach is well suited for developing a better understanding of complex ecosystem dynamics given data-poor and knowledge-vague settings.

*DO GREEN TURTLES PROTECT SEAGRASS TOP-DOWN AGAINST NEGATIVE EUTROPHICATION EFFECTS?

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Large grazer (sea turtle and sirenian) densities have declined rapidly in the last centuries, causing a shift towards seagrass beds dominated by smaller grazers (sea urchins and fish), which affects ecosystem functioning. Derawan Island (East-Kalimantan, Indonesia) is one of the few sites where high densities (15 turtle ha^{-1}) of green turtles (*Chelonia mydas*) are still present. Here turtles feed on *Halodule uninervis* dominated seagrass meadows and keep the seagrass meadows in the state of well-kept lawns. Increased coastal activities result in eutrophication, which threatens this essential food source for the green turtle. When nutrient pressure increases, irreversible shifts to a desert stable state are expected, caused by light limitation due to epiphyte or algal overgrowth. In this study we investigated the interacting effects of eutrophication and turtle grazing in an exclosure experiment. Here we mimicked green turtle grazing and eutrophication by fertilizing seagrass. Our experimental results and comparison with literature values indicated that the dominant seagrass species *Halodule uninervis* was not limited in growth by bottom-up factors (nutrients). In contrast, the seagrass was controlled top-down by turtle grazing. Grazing decreased length, width, density, and biomass, and increased export of nutrients. Grazing also provided a positive feedback by

stimulating seagrass production. In addition a strong relationship of epiphyte overgrowth after increased phosphate concentration was found. Under the combined effect of nutrient addition and grazing, intra-specific competition for nutrients between shoots is lower. Therefore nutrients were not limiting seagrass growth. Although fertilization created a situation where nutrients were abundant, and algae could profit from this by overgrowing seagrass, green turtles exported these nutrients and prevented overgrowth. Therefore strong grazing by green turtle densities prevents or delays the negative effects of increased nutrient loads. This yields insights into how green-turtle-grazed seagrass meadows function now and may have functioned historically. We discuss both theoretical and conservation implications of this finding.

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*ISOTOPIC TRACERS REVEAL CONNECTIONS BETWEEN ECOSYSTEM FUNCTION AND LIFE HISTORY VARIATION IN A STENOTROPHIC CONSUMER

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The ecological roles of sea turtles are often characterized in terms of the predator-prey relationships, the value of turtles as nutrient transporters, and their role in shaping coastal ecosystem structure. While these themes focus on the functional role of sea turtles in marine and coastal habitats, an important, albeit lesser studied aspect of sea turtles is their role as an indicator of ecosystem dynamics. Here we use stable isotopes to explore the ecosystem function and ecosystem indicator 'roles' of leatherback turtles (*Dermochelys coriacea*) in the Atlantic and Pacific Oceans. We describe leatherback trophic niche width and predator-prey linkages at two major foraging areas, and we further resolve the spatial distribution of nitrogen fixation and denitrification processes in both oceans. We measured the stable carbon and nitrogen isotopic ratios in skin samples collected from more than 400 leatherbacks, including individuals nesting in St. Croix (USVI), Gabon, Pacific Costa Rica, Solomon Islands, Papua New Guinea, and Indonesia, and individuals foraging in waters of Nova Scotia (Canada), U.S. West Coast, and Southeastern Tropical Pacific. Our results confirm the stenotrophic status of leatherbacks, and provide the first-ever direct comparisons of the isotopic niche width of leatherbacks assembled at the world's two most thoroughly studied foraging areas, found in Nova Scotia and California. When linked with spatial data on nitrogen cycling regimes, our stable nitrogen results showed a clear dichotomy between turtles inhabiting areas of denitrification (i.e. oxygen depleted zones) versus those living in areas with substantial nitrogen fixation. These results were consistent with habitat use information gained via satellite tracking of individuals for which isotope ratios were known, thus illustrating the role of sea turtles as indicators of ocean processes. To our knowledge, this study represents the largest collaborative effort undertaken for sea turtle stable isotope research to date, the results of which have provided a novel glimpse at the role of leatherback turtles in ecosystems and ecosystem studies throughout the world.

EDUCATION & ADVOCACY

*USE OF INNOVATIVE TOOLS FOR AT SEA OUTREACH: RADIO CONSERVATION FOR AT-SEA DECISION MAKERS

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Addressing conservation of marine protected species such as sea turtles in artisanal fisheries is challenging, partly due to the remoteness of many fishing communities, which makes enforcement of any regulations difficult. Peruvian fishing vessels that incidentally catch sea turtles often conduct trips offshore for more than two weeks and therefore use HF (high frequency) radio for communications. We therefore implemented the use of a HF radio based in Lima to communicate with vessels in real time during their fishing trips with the purpose of (1) maintaining real time and personalized communication with artisanal fishermen from different ports along the coast, (2) obtaining information about the catch and/or sighting of turtles during fishing operations, (3) providing technical information on safe handling and release of turtles, and (4) increasing awareness and encouraging sea turtle conservation among the fishermen who were contacted. Radio broadcasts occurred daily from January to June 2009. The results from the radio broadcast were a total of 246 communications with 178 fishers from 155 artisanal fishing vessels. The daily rate of radio contacts was 2–5 fishermen with an average talk time of 20–30 minutes each. Longline and driftnet vessels from 14 Peruvian ports, as well as vessels from southern Ecuador and Northern Chile were reached, giving a broadcast range spanning about 2,500 km of coastline. Twenty-eight fishers have sent follow-up contacts and seven fishermen individually traveled to our Lima office to get educational materials and information about sea turtle conservation. During 131 communications (53%), fishermen reported sea turtle interactions. These included 553 sea turtles observed and 957 sea turtles captured – either entangled (n=444) or hooked in longlines (n=513). A total of 46 leatherback turtles were reported (31 sighted, 9 entangled, 4 hooked and 2 dead). Fishermen (n=126) also requested weather information (78%), educational material about marine turtles (11%), or for the delivery of de-hookers (11%). On two occasions we assisted damaged or drifting vessels in contacting the authorities and their families for further assistance in coordinating their rescue. We conclude that the use of HF radio is an easy and affordable way to get information from a wide geographic area about captures and at-sea distribution of sea turtles and other marine fauna. If well designed, use of this tool can also provide a platform to conduct rapid assessments of local fisheries. HF radio can be used to provide direct, personal contact with the main stakeholders involved in turtle conservation at sea. The frequency of contacts through radio can provide an opportunity to establish a relationship of trust with individual fishermen located in remote areas, provide them with real-time oceanographic data (SST, wind speed), pass on the potential benefits to their fisheries and sensitize and encourage fishermen to participate in marine species conservation.

ENVIRONMENTAL PSYCHOLOGY: A SUCCESS STORY OF TURTLE CONSERVATION

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Kurt Lewin's 'field work' theory changed conservationists' perceptions towards the environment. It revealed the instincts of nature in human beings. These instincts needed to be boosted at the right time in order to generate interest in conservation activities. Turtle conservation on the western coast of India, if linked to this theory, is a massive positive feedback in the conservation of the olive ridley (*Lepidochelys olivacea*). This project for olive ridley conservation is a great success story as a result of people's participation. There are no olive ridley 'aribadas' on the western coast, but a good amount of nesting was observed. From 2002, an operant approach towards sea turtle conservation was built by Sahyadri Nisarg Mitra Mandal. Maximum focus was on people's participation in conservation. Here the status of olive ridley turtles was explained to the locals and a need for their protection was

expressed. Certain questions like the profit to locals, their role, and awareness in upcoming generations were considered. A strategy was designed to solve all the questions and implementation of ideas was done. Results of this work at the end of 2008 are around 155 nests protected with 7,884 individuals released in 2008 alone. The number of people getting involved in the activity and awareness generated is also increasing. Thus the conclusion is that the greater the advancement in environmental psychology of local people the greater the protection rate of the turtle population.

ProTECTOR – COORDINATING SEA TURTLE RESEARCH AND CONSERVATION IN HONDURAS

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Although situated among Central American nations making important contributions to sea turtle research and conservation, extremely little information has been forthcoming from the country of Honduras regarding the status of any turtle species found in its national waters. Very few reports of the presence of nesting turtles are on file, with the majority of these being outdated and providing only limited anecdotal information. There are even fewer published works reporting research and conservation efforts on any aspect of sea turtle biology in the country. With coastal areas and islands in both the Western Caribbean and Eastern Pacific regions, the waters of Honduras provide foraging and breeding grounds for *Eretmochelys imbricata*, *Chelonia mydas*, *Caretta caretta*, *Dermochelys coriacea*, and *Lepidochelys olivacea*, and are therefore worthy of considerable research efforts. Recently, the Protective Turtle Ecology Center for Training, Outreach, and Research (ProTECTOR) has engaged government agencies and NGOs in Honduras in support of a program to initiate and coordinate research and conservation efforts on all five turtle species present in the country. To date, ProTECTOR has tagged over 300 turtles, including *E. imbricata*, *C. mydas*, and *L. olivacea*, in both the Caribbean and Pacific regions of the country, as well as mapped hundreds of dive and aerial turtle sightings. Government agencies have requested that ProTECTOR further expand research efforts to sea turtle populations which have not yet been investigated throughout Honduran waters.

LAUNCH OF SEA TURTLE WEBSITE FOR BANGLADESH

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The research organization Marinelife Alliance is starting a web based sea turtle information system for Bangladesh territory (www.seaturtlebd.org). The site will contain information on research and conservation gathered by various researchers since the 1970s. Until now, there has been little field based work done along the coast and marine waters in Bangladesh and hopefully this web information will help create new perceptions in understanding research needs and highlight the current efforts made. Current topics included nesting and foraging species, population status, threats, fisheries interactions, coastal development and reduction of nesting rookeries, satellite telemetry, genetic studies and conservation efforts. The website will include links to websites throughout the world with special emphasis on networks related to south Asian and Bay of Bengal countries. Although we have limited power sources, the organization will also provide free view and use of the website in all Marinelife Alliance education centers in Cox's Bazar. Community members living in remote areas will be able to use such facilities and can get their work visible throughout the world as it is uploaded. This will tremendously increase the mental stamina and the awareness level in the local community and will certainly reduce anthropogenic impacts on sea turtle in our country.

SEA TURTLE EDUCATION AND REHABILITATION CENTER IN BANGLADESH

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One of the priorities for sea turtle conservation work is getting the local community involved through education and raising of awareness. Marinelife Alliance is setting up such an education center along Cox's Bazar coast in Bangladesh. Under the education and awareness program, we have reached over two thousand school students in 21 primary and secondary schools, more than five thousand local people and 173 offshore fishermen leaders, providing information on sea turtle conservation and bycatch reduction. Sea turtle life cycles and critical stages and different country project activities are shown in various awareness programs conducted by our STER center. Currently more than 2,000 square feet of printed information is on display. The development of a sea turtle rehabilitation center is underway as we now have obtained a swimming tank that would allow for a short-term enhancement program. Fishermen can provide valuable information and can participate to reduce threats inwater.

SEA TURTLES IN NORTHERN NEW SOUTH WALES AND SOUTHEAST QUEENSLAND

Jann Gilbert

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The Australian Seabird Rescue (ASR) poster/brochure is designed to educate and raise awareness of the general public with regard to turtle conservation and research in northern New South Wales, Australia, and ASR's work in turtle rescue, rehabilitation and research. Information includes an overview of turtle species, habitats, lifecycle, threats, ASR's turtle hospital and rehabilitation centre, volunteer projects and how to help (including a determined effort to make ASR's hometown plastic bag free), a code of conduct for turtle watchers and ASR contact information. The poster folds into a brochure for greater convenience and easy handling. ASR is a volunteer organisation dedicated to rescue, rehabilitation and research on seabirds, sea turtles and marine mammals. It operates a turtle hospital and rehabilitation centre on the far north coast of New South Wales in Australia, and runs training and educational programs as well as guided tours of the centre and its work. ASR rescue services cover the coastline of New South Wales from Tweed Heads to the South Coast. It operates on a very limited budget and with a predominantly volunteer staff. Its 'Make Turtles Count' program, was presented at the 2009 symposium in Brisbane.

OUTREACH, PROTECTION AND CONSERVATION OF *CARETTA CARETTA* IN MAIO ISLAND, CAPE VERDE, WEST AFRICA

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There are three main islands used by nesting turtles in Cape Verde: Boavista, Sal and Maio. These islands support a nesting population of loggerheads (*Caretta caretta*), thought to be the third largest colony in the world. Maio is the least protected in terms of sea turtle conservation. Implementing a project here faces challenges such as extensive beaches, difficult access, lots of flooding areas and traditional culture, with people hunting nesting loggerheads as well as illegally taking eggs. In Maio egg consumption is a serious matter, reaching almost 70% of the clutches on some beaches, whilst in Sal this affects only 1% of the nests. Maio lacks the seriousness of a proper conservation structure. The local government already has a number of guards patrolling the beaches, but their reliability is questionable whilst other interested parties lack the proper knowledge to work with the turtles without disturbing the nesting activities. Under the directives of the newly founded CVSTN (Cape Verdian Seaturtle Network) and SOS Tartarugas (Sal Island), it was possible to undertake the first complete census of the island which found 548 activities (nests and false crawls) gathered over 4 days. We were able to collect information on the nesting beaches to assess population density in order to prioritise future efforts. Identifying flooding areas and areas in which illegal

take of eggs was occurring was one of our objectives and we gave support and training to guards and local government officials throughout the season. We initiated outreach campaigns in the community informing people about the importance of the turtles in the wild and the effects of captivity as well as teaching the biology and life cycle. The objective of these activities was to change the way local residents view turtles, informing them of the threatened status and the economic potential of a nesting congregation. There is a need for immediate protection and conservation of this population as development is still in early stages and we can work with developers and locals alike to create a sustainable turtle-friendly island. We started working with several active members of the local community and ran groups of workshops and training sessions along with nighttime visits to the nesting beaches so people could witness the process. These actions were supported by the city hall, local authorities (also involved) and local businesses. This had a strong impact on the community and outreach activities were viewed as a positive experience for all, assuring the interest and feeling for protection of the species. All the people involved during the course of these actions were very committed, but after the departure of our delegation from Maio Island things fell into oblivion and no more efforts were made to improve and continue the work begun during our stay. There is a need for a hatchery, active beach protection and a tagging program to progress the ongoing task of saving sea turtles and developing a successful community based conservation project.

INTEGRATING LOCAL COMMUNITIES INTO WILDLIFE CONSERVATION ON BIOKO ISLAND, EQUATORIAL GUINEA, AFRICA

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The local community of Ureca has been collecting sea turtle nesting ecology data on the southern beaches of Bioko Island since 1998. Our goal was to: 1) reassess the data collection regime from the past 11 years; 2) educate the local community and local university students in sea turtle nesting ecology; 3) train census takers for more accurate data collection. We patrolled the nesting beaches with the local census takers during the 2007–2008 nesting season and compared our data to their collected data. During the 2008–2009 nesting season, we educated the local community and students as well as trained them in census taking through weekly visits to the village over six months. During these visits we explained turtle nesting ecology and solved problems that they encountered while on census. We incorporated the use of GPS units to improve supervision and data collection. We found that it is very important to have onsite supervision for better data collection. Our efforts for better education and training of the local community improved the quality of data. Lastly, having local people on the nesting beaches not only decreased the number of turtles poached but also helped decrease the number of primate hunters in the area.

COMMUNITY AWARENESS AND CAPACITY BUILDING IN SEA TURTLE CONSERVATION IN SRI LANKA

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The TCP's community awareness and capacity development programs included conducting a training workshop, field training, vocational training, school lectures, exhibitions, film shows etc. TCP's community capacity development programme has turned the turtle egg poachers into nest protectors. Thirty-two former egg poachers have been employed as nest protectors in Kosgoda and Rekawa villages. Furthermore, with the assistance of the Sri Lanka Tourist Board (SLTB) TCP trained these local villagers and licensed them as eco tour guides. In addition, TCP has formed small community groups or Community Based Organizations (CBOs) such as the Community Batik Group, Community Sewing Group, Community Ornamental Fish Breeding Group, Community Coir Group and Turtle Nest Protector Groups in Kosgoda and Rekawa villages in order to implement various community livelihood development projects. Developing the capacities of CBOs facilitated the TCP's implementation of various community projects. Through the education and awareness projects in these villages, TCP was able to change some of the negative attitudes of the local fishermen on marine and coastal resources that led them to over-

exploit the resources. In addition, TCP has also implemented community skills development programs such as primary school programs, computer classes, free English language classes, sewing training, disaster preparedness training, etc. Children's clubs were established in order to involve children in the coastal ecosystem conservation and management process, providing them with necessary awareness through various educational programs. The target groups of TCP's awareness and capacity development programs included local fishermen, school children, the general public, wildlife officers, NAVY and Police officers, tour operators, academics, etc.

*WHERE SCIENCE AND CONSERVATION COALESCE; INDIAN CITIZEN INITIATIVES AND MARINE TURTLES

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Population dynamics of marine turtles can be best understood through long term monitoring. The most systematic technique is offshore monitoring, but this is too expensive to carry out across vast areas of coastal water. In India, the olive ridley turtle nests along the coast of six states: Orissa, Andhra Pradesh and Tamil Nadu on the east and Kerala, Karnataka and Maharashtra on the west coast. The dynamics of this population of olive ridleys is little known, as offshore monitoring is prohibitively expensive. Onshore monitoring can act as a surrogate, giving us indices of population size, shifts and fluctuations. Hence we, along with groups and organizations that are already involved with sea turtle conservation along various parts of the Indian coast, have established an onshore monitoring programme. This long-term initiative could provide insights into the biology/population dynamics of olive ridleys that nest along Indian shores. Eight local community-based conservation groups dedicated to sea turtle conservation have agreed to collect scientific data. They have been trained and provided with the necessary equipment to collect data that will be pooled into a growing database of turtle nesting locations, clutch sizes, hatching rates and nest temperatures across the six states where the olive ridley nests. The groups have also begun to share information and expertise amongst themselves. This initiative has helped us identify the specific threats that affect these turtles along different regions of the Indian coast, such as the sea walls and oil pipelines along parts of the Maharashtra coast. There are distinct patterns of nesting along the two coasts. The timing of nesting appears to be linked to the monsoon. Temperature regimes are also influenced by the timing of nesting during the year, potentially generating dissimilar sex ratios along the two coasts. Eventually this data could be used to understand turtle population dynamics and genetics and model the impacts of climate change on the temperature dependent hatchlings.

OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) CONSERVATION AND AWARENESS THROUGH COMMUNITY PARTICIPATION IN MAHARASHTRA, INDIA

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Of the seven species, five species of marine turtles are found in Indian waters. The olive ridley is the most abundant sea turtle in India (Rajgopalan 1984). The olive ridley nesting season starts from October to March along the coast of Maharashtra, where sporadic nesting of olive ridleys is reported with a few potential beaches in Sindhudurga and Ratnagiri district (Giri and Chaturvedi 2003). Sahyadri Nisarga Mitra (SNM) is a leading NGO working on nature conservation, protection, education, and research since 1992. While on status surveys for the white-bellied sea eagle (*Haliaeetus leucogaster*) along the coast of Maharashtra, SNM found evidence of marine turtle nesting on the coast of Velas, a tiny village in Ratnagiri district. SNM started the study and conservation work for marine turtles in Maharashtra, India from 1 October 2002 and in 2007 launched the UNDP GEF SGP, CEE Central supported project "Marine Turtles Conservation and Awareness through Community Participation" in Maharashtra India. SNM completed a status survey of the entire 720 km coastline of Maharashtra state India. Main threats are poaching of eggs, poaching of adults for meat, habitat destruction and trawling. Conservation of marine turtles, community participation, and linkage of eco clubs, youth clubs and SHGs to give an alternate income source are the objectives of the project. SNM undertook conservation work and an olive ridley awareness campaign through a hatchery management programme in 30 coastal villages along the Maharashtra coast. Also undertaken was an awareness campaign on the entire coastline of Maharashtra. Outcome: during the years 2002 to 2009, 530 nests were protected

and 25,000 hatchlings were released into the sea in Maharashtra. To promote livelihood activity, SNM started a Turtle Festival at Velas. Tourists visited this event in large numbers. Observation of hatchlings crawling towards the sea, a film show, debate and nature activities are the programs. All the hatchery related work is under our volunteers' control. Additionally, Kasav Mitra Mandal (KMM) was established at Velas. A small group from Velas actively participated in this conservation and livelihood together activity for the first time in India. The members of KMM provide homely lodging and boarding facilities at reasonable rates and donate a small part of the income to a turtle conservation fund which is utilised for turtle conservation activities in the village. SNM established the Marine Turtle Knowledge Information Centre (MTKIC) at Velas. SNM published a booklet in Marathi and Gujrati (local languages) by Ram Mone and Bhau Katdare and freely distributed it to volunteers and published a DVD Kasav Tuzachsathi (Turtle for You) depicting the entire lifecycle of marine turtles. Each year, SNM gives an award 'Kasav Mitra' (Turtle Friend) to someone who has made outstanding contribution to marine turtle conservation in Maharashtra.

MANAGEMENT OF SEA TURTLES IN ZANZIBAR

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The purpose of sea turtle conservation in Zanzibar is to raise awareness in the community so as to save the sea turtle. Five species of sea turtle are recorded in Zanzibar waters (green, hawksbill, loggerhead, leatherback and olive ridley), two of which nest on the island's beaches (green and hawksbill). There is long history of exploitation of sea turtles in the Indian Ocean. People in Zanzibar have traditionally used turtles for food and medicinal purposes. The populations of sea turtles in Zanzibar have declined to a fraction of what they once were due to various human impacts. Since 1990, Zanzibar has made efforts to conserve sea turtles. A successful campaign on local trade in turtle products culminated in the symbolic burning by the government of many turtle shells, which took place in 1995. Prior to that, these products were sold openly in Zanzibar. The paper elaborates on the critical threats to the sea turtles of Zanzibar which include: destruction of nesting beaches by tourism development, slaughter of adult turtles for meat and medicine – both at sea and on nesting beaches, consumption of turtle eggs, stranding in gill nets (*jarife*), and lack of enforcement. The paper provides detailed information on data provided by turtle contact personnel, which originated from 29 villages in Zanzibar as well as Misali and Mnemba Island. Data from the year 2000 includes information on nesting seasons, hatching of the nests, stranded turtles on beaches, and data on gill net catches as well as a tagging programme. Nesting surveys and education campaigns have resulted in the generation of important information which helps in the establishment of a conservation action plan. As an important step for the conservation of sea turtles in Zanzibar we have initiated the establishment of the Zanzibar National Sea Turtle Conservation Committee in February 2002. Sea turtles in Zanzibar are protected by the Fisheries Act, Forest Management Act and Environmental Act.

INVOLVING COMMUNITY FOR OLIVE RIDLEY CONSERVATION IN NELLORE, ANDHRA PRADESH, INDIA

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This poster illustrates our efforts to extend conservation of olive ridley sea turtles in Nellore, Andhra Pradesh, India by involving the fishermen community dwelling in the coastal fishing villages. The coast of Nellore is a nesting site of endangered olive ridley sea turtles. In October 2008, TREE Foundation learned the disturbing news that Tribals were poaching nesting sea turtles and their eggs in Nellore, Andhra Pradesh, despite the protection of sea turtles under Schedule - I of the Indian Wildlife Protection Act of 1972. In order to end this three-decade-old practice and to protect the highly endangered sea turtle population, TREE Foundation extended its successful community based sea turtle conservation program to 14 villages along the Nellore Coastline on the southeast coast of India in the Bay of Bengal region. An urgent solution was required and that initiated a pilot program for sea turtle conservation (similar to one currently running in Chennai) immediately in the 14 fishing villages (covering 20 km). TREE Roots & Shoots – Nellore (a youth volunteer group of TREE Foundation) volunteers coordinated the project, and 12

volunteers from the local fishing community were initially trained in protection of nesting turtles and monitoring of hatchlings by in-situ and ex-situ conservation methods. The 12 fishing community volunteers assisted TREE Foundation as Sea Turtle Protection Force (STPF) members for the 2008–2009 turtle season. The fisher volunteers have established three hatcheries – one each in Ramachandrapuram, Venkatanaranapuram and Lakshmipuram. In total, 38 nests were protected and 3,262 hatchlings were safely released. This poster also elucidates the methods of motivation adopted to spread awareness of the role and importance of sea turtles in the coastal bio-diversity. The main programs conducted for educating the uneducated fishing community are documentary, slide shows and youth workshops through martial arts training for men, forming self-help groups, and sea turtle awareness programs for the trawl boat and mechanized fishing community. It also explains the methods pursued to check illegal poaching – the awareness programs conducted to educate about wildlife act and the ecological importance of marine and all wildlife. The most significant step was the networking with the Department of Forest (Wildlife Wing) and the Department of Fisheries for an effective sea turtle habitat conservation program.

TAMAR SINGS TO CELEBRATE ITS 30TH ANNIVERSARY

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[3] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Ubatuba, São Paulo, Brazil
[4] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Vitória, Espírito Santo, Brazil
[5] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Pirambu, Sergipe, Brazil
[6] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Natal, Rio Grande do Norte, Brazil
[7] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Almofala, Ceará, Brazil
[8] Projeto TAMAR-ICMBio -Fundação Pró-TAMAR, Itajaí, Santa Catarina, Brazil

Projeto TAMAR (the Brazilian Sea Turtle Conservation and Research Program) is celebrating its 30th anniversary and has found a different way to tell the stories lived throughout these decades. A special musical selection has been recorded to sing away the tales, curiosities, achievements and adventures of sea turtle conservation. Together with various songs composed by fishermen and locals from the small villages, new lyrics were written, and all were remixed and sung by famous Brazilian singers who support the cause. During this celebration season, local bands, folk groups, and other cultural manifestations, are being encouraged to open the concerts held by famous artists, at the visitor centers, promoting local culture, and creating a great sense of participation within the communities. TAMAR´s long journey started in 1980 with a big challenge: to understand and protect sea turtles along our coast. The program now comprises a network of 23 research stations covering approximately 1,100 km of the Brazilian coastline and oceanic areas, generating jobs for about 1,300 people – 85% of which belong to the local communities. Everything was built based on a learning-by-doing process, with the communities, associated to government realities, and the needs for sea turtle conservation. The strategies applied have reduced drastically the harvesting of eggs and turtles. The partnership between different sectors of society, including government, private companies and NGOs, was the key to overcome the difficulties found along the way, and to reach conservation goals. The direct participation of coastal communities in sea turtle conservation activities, since the beginning, such as in the fieldwork, eco-tourism, and manufacturing products using sea turtles as a symbol, is essential to assure sustainability of long-term results. The TAMAR modus operandi has inspired many organizations within the country to work on marine conservation. Over the past 30 years, it has been a practical school for young professionals. Educational programs and outreach are developed creating bridges between sea turtle protection activities and the reality of the communities, promoting a better standard of life through health, capacity building programs, generation of jobs, etc. The supported ecologically sound and economical alternatives take under consideration features of each individual community, as well as the economic viability of every proposed activity. Visitor Centers strategically located in some stations are important educational tools to communicate the importance of marine ecosystems, through sea turtles. They are also a unique source of income and generation of jobs for the local communities through gift shops, eco-tourism, guided visits, restaurants, etc. TAMAR has proudly published the results of a long term trend analyses for the numbers of nests laid by four species that nest along the Brazilian coast. These positive results drive us to work towards the continuity of our activities, targeting the new challenges for sea turtle conservation, such as coastal

development, fisheries interaction, debris and others, adapting according to the new realities, but always with the same ideals that have led to this successful community based research and conservation program.

FOUNDING A MARINE ENDANGERED SPECIES WORKING GROUP IN NEW YORK, USA

A. Nicole Mihnovets

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Approximately ten million people inhabit New York's coastal and marine district. New York waters support one of the busiest ports in the United States, as well as other economically important industries such as commercial fisheries, alternative energy development, and marine recreation. This region of the Northwest Atlantic Ocean is seasonally inhabited by state, federally, and CITES listed marine endangered species including four species of sea turtles (green, loggerhead, Kemp's ridley, and leatherback) and at least four species of whales (humpback, finback, sei, and North Atlantic right whales). Yet, the full extent to which these species use New York waters and are threatened by anthropogenic activities remains unknown, thereby hindering comprehensive management and conservation efforts. To address this knowledge gap, the New York State Department of Environmental Conservation (DEC) convened two expert workshops in 2006 and 2008. During the first workshop, experts from nongovernmental organizations, academic institutions, commercial fisheries, and local, state, and federal government agencies reviewed best available data, identified known threats to marine endangered species, and recommended solutions to mitigate these threats. During the second workshop, experts modified and expanded previous recommendations, set realistic short-, medium-, and long-term conservation goals, and considered opportunities for collaboration. Experts also discussed how a common misperception of New York as a biodiversity-deficient area, combined with gaps in baseline biological data, often leads to underestimation of potential threats to sea turtles and whales in waters off of New York and throughout the greater mid-Atlantic region of the United States. Seeking solutions for this dilemma, experts targeted key objectives towards informing management, promoting conservation-minded policies, and fostering public awareness, which include activities such as gathering new data, synthesizing existing data, and disseminating findings. To begin addressing these objectives in a complementary and efficient manner, experts unanimously agreed it was necessary to establish a formal New York Marine Endangered Species Working Group (NYMARES). Since its inception in October 2008, NYMARES has formulated a vision and mission statement, has held quarterly conference calls, and has identified and applied to funding opportunities for collaborative research and conservation initiatives. Ongoing dialogue is facilitated by the NYMARES listserv generously supported by Seaturtle.org. A third expert workshop is expected in October 2010. The progress of NYMARES to date demonstrates a new capacity to reach a broad stakeholder audience, and to foster cooperative relationships capable of strengthening the scientific basis for future marine endangered species conservation and management efforts in New York.

*BRIDGING CULTURAL AND SOCIOECONOMIC GAPS THROUGH SEA TURTLE CONSERVATION: A SISTER-SCHOOL PROGRAM IN THE MEXICAN PACIFIC

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Partnership and outreach programs have been advocated as a way to bring together schools and local communities and allow them to become stakeholders in research and conservation efforts. Since 2002, Mar y Tierra, a Mexican NGO, has been working with the Playa Ventura community in Guerrero for the conservation of olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*) turtle populations. This year, we are launching a new program that brings together urban students from private high schools in Mexico City with high school students from the rural community of Playa Ventura for 4 days. The urban students come mostly from European-Mexican backgrounds, while the Playa Ventura community is one of the only Afro-Mexican communities in the country. A pilot study was conducted in November 2009, where 20 students from Mexico City came to Playa Ventura and met members of the local community school. They helped local conservationists with night patrols, data collection, maintenance of the hatchery, and liberation of the hatchlings. The Playa Ventura community assisted in these activities and led talks about their history and traditions. Finally, the students were guided in the design of a

collaborative project that connects the experience in Playa Ventura with the urban environment of Mexico City. Through experiential and intergenerational education this project aims to (1) assist in the conservation and restoration of the Eastern Pacific leatherback and olive ridley populations, (2) raise awareness about the coastal ecosystems and endangered species and foster a sense of ownership and responsibility in the local community, (3) facilitate collaboration, and cross-cultural and intergenerational education to bridge socioeconomic and cultural gaps by bringing together two communities around a common concern, sea turtle conservation, (4) link the environmental degradation in coastal ecosystems to actions and choices in large cities and help students fulfill their role as environmental citizens in their urban environments. Pre and post-tests as well as round tables with the students, teachers and members of the Playa Ventura community will be performed to review and improve the program design. This pilot study will be the start of an ongoing, long-term evaluation project, where we will test the effectiveness of the program in accomplishing the above stated objectives.

SEA TURTLE HATCHERIES AS TOOLS FOR EDUCATIONAL AND COMMUNITY-DEVELOPMENT ACTIVITIES ON THE PACIFIC COAST OF GUATEMALA

Miriam Monterroso

Wildlife Rescue and Conservation Association

Sea turtle conservation in Guatemala has relied almost exclusively on the use of community-based hatcheries operated by a variety of actors, usually with minimum budgets and a lack of technical expertise. The Wildlife Rescue and Conservation Association (ARCAS) operates two of the most productive and well-managed of the 21 hatcheries operating in the country. It has strived to take full advantage of these hatcheries to carry out a variety of environmental education, community development and ecotourism activities. This presentation looks at the ways that hatcheries can be incorporated into integrated coastal zone management, especially their use as centers for environmental education, volunteer-based ecotourism, and gender and community-based research.

EDUCATION AND OUTREACH: AN IMPORTANT ELEMENT IN THE PROTECTION OF LOGGERHEAD SEA TURTLES ON THE ISLAND OF CRETE, GREECE

Aliki Panagopoulou, Maria Stravaridou, and Dimitris Margaritoulis

ARCHELON, Athens, Greece

Crete hosts three important nesting areas for loggerhead turtles in Rethymno, the Bay of Chania and the Bay of Messara. ARCHELON has been running conservation projects in these areas since their discovery in 1989–1990. An important element of these projects is the environmental education and outreach program. The main aim of ARCHELON's education program on Crete is to provide information about sea turtles and the threats to their survival. These are related to the negative impact of tourism development and the increased mortality because of their accidental capture in fishing gear. A successful education and outreach program relies on the ability to reach many different target groups, each of whom is a stakeholder: tourists, workers in the tourism industry, local community members, children, fishermen and their families, local authorities, etc. As marine turtles are such a charismatic species, they are used as a means to promote the protection of the natural environment by influencing the public to adopt practices that are not harmful to it. Further, successful education and outreach will also increase support towards the protection of sea turtles among all stakeholders involved, thus setting the framework for the initiation of collaborations to that effect. To achieve this, ARCHELON utilizes several means: during the summer, the peak of both nesting and tourist season, education activities focus mainly on tourists – but are also addressed to the local community. Three information stations, at strategic locations in Rethymno, Chania and Matala, reach about 50,000 people annually. Slide presentations, designed both for children and adults, are given within tourist businesses along the nesting beaches reaching about 15,000 people. Information is also provided during field work (10,000 informed per season). The local community is informed throughout the year, through the media in the form of press releases, articles or interviews or through participation in local events. ARCHELON has also been conducting a year-round environmental education program addressed to school children with live presentations and portable educational kits. In 2005, in the course of a LIFE-Nature Program, ARCHELON established an Environmental Information Centre in Pangalohori, Rethymno, which has since informed more than 4,000 students. ARCHELON's portable exhibition, titled "Mediterranean Sea, Fishermen and Turtles" has been instrumental in

reaching people in other areas throughout the island. Finally, special presentations, designed for workers in the tourism industry and local authority representatives are also regularly given – usually before the start of the nesting season. In conclusion, ARCHELON's education and outreach program reaches 200,000 people per year. It has been very useful in reducing the pressure on the turtles on the beach at night, in achieving collaborations with stakeholders and more importantly it has been instrumental in gaining support and respect of the general public with regards to ARCHELON and the protection of sea turtles on the island. Acknowledgements: ALP would like to acknowledge support received from the Lee Smith endowment at Drexel University. Special thanks are due to the ISTS organisers and sponsors whose support has also made it possible to participate in this meeting.

KUWAIT TURTLE CONSERVATION PROJECT AND SENYAR VOLUNTEERS: A SUCCESS STORY

Nancy Papathanasopoulou[1] and Ali Alhafez[1,2]

[1] Kuwait Turtle Conservation Project, Kuwait
[2] Senyar, Kuwait

Kuwait hosts two species of nesting turtles, the green and the hawksbill. However, loggerheads and leatherbacks have been recorded in Kuwaiti waters and reports of possible loggerhead nesting were provided by local populations and researchers several years ago. The Kuwait Turtle Conservation Project, sponsored by TOTAL Foundation and TOTAL Kuwait and under the auspices of the Voluntary Work Center of Kuwait and The Scientific Center of Kuwait, began its research and conservation work on offshore islets Qaru and Umm Al-Maradim in July 2008. The program is expected to last three years. After two nesting seasons, the information gathered indicates that sea turtle populations are low in these areas and they fluctuate from year to year. High temperatures in the summer, reaching up to 60 degrees Celsius are making field work challenging but interesting. Green turtles dig enormous pits to nest in and usually make several attempts before nesting. No information about hatching success is available yet, as the project is still in its beginnings. I-buttons and satellite tracking are part of the project. A vibrant coral reef surrounds both islets, with Qaru showing a particular wealth in coral, fish, invertebrates and other interesting species, such as what seems to be a resident bottlenose dolphin (*Tursiops truncatus*) pod which has been encountered by project divers a number of times. The presence of multiple juvenile tropical fish indicates the ecological importance of Qaru Island as a nursery for the region. Oil often seeps naturally through the sea bed creating considerable "natural oil spills" around Qaru. It is remarkable that the sea life does not seem particularly disturbed by these spills. Senyar, a long-term project of the Voluntary Work Center of Kuwait, was launched in 2004, entirely manned by volunteers and with the purpose of protecting the marine environment of Kuwait. Volunteering for the environment is not a known value in this geographical region and Kuwait's Voluntary Work Center (VWC), initially inspired many years ago from the invasions in the country, is a pioneering institution in inspiring volunteerism in an Arabian Gulf country. Senyar is one of the teams of the VWC and has inspired over 50 male and female Kuwaitis to enroll and work as one on an ambitious artificial reef project, a mooring buoy project, beach cleanup projects, a search and recovery project, specialized advanced diving missions (from trained commercial divers who are volunteers) and active participation of the protection and rescue of marine life. Emergency missions are also organized in support of the government when an environmental crisis occurs. KTCP is operating under the umbrella of Senyar and members of the Senyar team are also active members of the turtle conservation project team. It is hoped that after KTCP delivers its results in two years, its work will be continued and enhanced by Senyar.

COMMUNITY CONSERVATION – A COMPREHENSIVE APPROACH FOR SEA TURTLES ALONG KANCHEEPURAM COAST, INDIA

T. Raja[1], A. Saeef[1], and Supraja Dharini[2]

[1] Sea Turtle Protection Force (STPF) of TREE Foundation, 63 First Avenue, Vettuvankeni Chennai, India
[2] Chairperson, TREE Foundation, 63 First Avenue, Vettuvankeni Chennai, India

This poster illustrates our efforts for community based conservation of olive ridley sea turtles involving the fishermen community in the coastal fishing villages in Chennai, India. The coast of Chennai is a nesting site of the endangered olive ridley sea turtle. The nesting beaches of fishing villages such as Periya Neelangarai, Injambakkam, Panaiyur, Nainarkuppam (Uthandi) and Reddy Kuppam – Kanathur are patrolled by the youth of the fishing communities of respective villages. They have been initiated by the Tree Foundation from the year 2002 to protect and relocate the eggs and release all hatchlings to the sea on a volunteer basis. These volunteers are known as the "Kadal Aamai Padhukavalrgal" (Sea Turtle Protection Force). This initiation of community conservation of the olive ridley sea turtles has successfully progressed over the last seven years. This poster also elucidates the methods of motivation adopted for outreach programs used for the fishing community, school and college students and the general public to spread awareness of the role and importance of sea turtles as flagships for 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 all the above people more environmentally sensitive and to encourage them to take action to become ambassadors for the ocean. The main programs conducted for educating the artisanal fishing community are one day environmental education workshops for the youth and children at zoos, sanctuaries, etc., slide shows, sand modelling competitions, street plays, puppet shows, peace rallies, the Pungamiya plantation for bio-diesel 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.

CAMPAIGNING FOR SEA TURTLES IN 5 EASY STEPS

Rebecca Regnery, Danielle Annese, and Heather Tallent

Humane Society International, USA

Anyone can be an advocate for helping sea turtles. You do not need any prior experience or expert knowledge, just the will and determination to speak on behalf of the turtles. There are five easy steps to becoming an effective international sea turtle campaigner: 1) do your homework, 2) team up with others, 3) get to know your government, 4) work on international agreements, and 5) ask the public to join your cause. First, research your country's wildlife and animal welfare laws. Find out which international agreements your country participates in or is eligible to join. Determine if laws need to be strengthened or adopted and where there are enforcement problems with existing laws. Gather evidence including statistics, pictures, and reports. Decide which issues you would like to focus on. Then find others who share your goals and mission and combine your efforts. Join or create a network of people like you – such as students, non-profit organizations or scientists. Together you will be able to strengthen your knowledge and efforts and have a stronger impact. Next become acquainted with the government officials that cover sea turtle issues for your local and national government. Learn what offices deal with the issues you have chosen to address and politely introduce yourself with a letter, email, phone call or meeting. Discuss the issues with them in a constructive and non-confrontational manner. Act as a resource they can use to help solve problems. Anticipate and answer their questions. Provide them with concise information. Don't forget to thank them! Take that a step further by finding out how you can participate in international meetings as an observer, as an advisor to your country's delegation, or on an advisory committee or panel. You may be able to write about the meeting for your local newspaper or on the Internet. An organization or coalition can do a joint statement or a press release before, during or after the meeting. And finally, enlist as many people as possible to help accomplish your goals. Reach out to your community to educate them about the issue. Tell people what specific action they can take such as signing a pledge, writing to a government official or corporation, or choosing not to patronize a certain establishment. Find an international group or network that shares your mission and goals and ask them to help. I will end with a few examples of interesting accomplishments!

SEA TURTLES IN AKUMAL, MEXICO: FINDING A BALANCE BETWEEN ECOTOURISM AND HARASSMENT

Monica Rosquillas[1], Armando Lorences Camargo[2], Miguel Angel Maldonado Cuevas[2], and Katherine Comer Santos[3]

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Akumal Bay lies about 100 km from Cancun, Quintana Roo, México. "Akumal" means sea turtle in the Mayan language, and the town is a popular tourist destination for foreigners, nationals, and locals, bringing high densities of swimmers and snorkelers to the waters. A major draw is the resident group of juvenile green sea turtles (*Chelonia mydas*) that feeds on the sea grasses in the clear shallow waters of the bay. Mexico's laws prohibit touching or harassing the turtles, and the Centro Ecológico Akumal (CEA) runs a strong educational program, but because of lack of enforcement, harassment is a concern. Too much harassment could stress turtles and possibly drive them out of the bay, changing the local ecology as well as the economy. Through The Science Exchange internship program and in cooperation with CEA, we collected interview data on tourists' knowledge of sea turtles' legal protection and also observational data on the behavior of tourists interacting with turtles in the water. Photo documentation of tourists snorkeling/swimming with turtles in the water was performed daily at the same time during June and July of 2009 while snorkeling set transects. A high percentage of tourists touched, chased after, and crowded the turtles. Average distance from tourist to turtle was quantified. During that same period, random intercept surveys of 114 tourists were administered on the beach. The eight questions aimed to determine how much tourists know about laws protecting turtles, among other goals. Results show that 67% of people surveyed were hoping to see turtles while snorkeling in Akumal, 47% did see a turtle, and only 4% admitted to touching turtles. Seventy nine percent of the tourists knew that sea turtles are protected in Akumal, but only 56% knew that turtles are a protected species in Mexico. Despite this indication that the educational campaign on sea turtle conservation in Akumal is reaching the majority of tourists, photo documentation shows a high percentage of swimmers/snorkelers were behaving in harassing ways. Recommendations include providing better definitions of appropriate turtle watching behavior in the educational campaign, providing training to snorkel tours and operators, implementing an enforcement program that issues fines to individuals who break the law, and/or fining the tour agencies who are supervising the snorkel tours.

PRESENCE OF NESTING OLIVE RIDLEY SEA TURTLES ALONG PONDICHERRY COAST, INDIA

Vimal Raj S.[1,2] and Supraja Dharini[1]

[1] Tree Foundation, Vettuvankeni Chennai, India
[2] Tree Roots & Shoots, Pondicherry, 63 First Avenue, Vettuvankeni Chennai, India

This poster attempts to explain our efforts to protect the highly endangered olive ridley sea turtles and their nests and how the olive ridley nesting beaches in Pondicherry are fast disappearing because of human activities. The smallest of the seven species of sea turtles worldwide is the olive ridley (*Lepidochelys olivacea*). It is a threatened species that is protected under Schedule I of the Wildlife (Protection) Act, on par with the tiger and the elephant. The decline of this species is primarily due to human activities, including the direct harvest of adults and eggs, incidental capture in commercial fisheries, and loss of nesting habitat. A conservation initiative was undertaken by TREE Roots & Shoots Pondicherry to protect the nests of the olive ridley along the coast. Most of the beaches along the fishing villages have not been monitored on a daily basis before. A Rapid survey was undertaken in 2008 by the fisher folk and TREE Roots & Shoots Pondicherry members to ascertain if turtles nest on these beaches. Awareness programs and interviews were conducted from December 2008 to January 2009. It was inferred from the communities' observations that about 10–15 turtles were observed in each village beach stretch before the sea walls were erected in most stretches. The methods used to ascertain the presence of nesting olive ridley were a monitoring program by the new recruited fisher folk and volunteers, patrolling of beaches, checking illegal poaching and maintaining data log books for nests and emerging hatchlings.

ENFORCING TURTLE PROTECTION LEGISLATION THROUGH THE ENGAGEMENT OF SCHOOL CHILDREN IN BAA ATOLL, MALDIVES

Marie Saleem[1], Asim Mohamed[2], and Thomas Le Berre[1]

[1] Seamarc Pvt. Ltd, Male, Maldives
[2] Four Seasons at Landaa Giraavaru, Baa Atoll, Maldives

Five species of turtles have been recorded in the Maldives out of which the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*) are found throughout the archipelago and breed regularly. The other three species, the loggerhead turtle, the olive ridley turtle and the leatherback turtle are not frequently observed in the Maldivian waters. Sea turtles have been traditionally harvested in the Maldives for trade and as a food source. The intensity of these activities in addition to habitat loss and perturbations led to declining populations. A 10 year moratorium banning the killing or catching of any turtle species was put into effect in June 1995 under Section 10 of Fisheries Law No. 5/87. However, turtle eggs were not included in the ban on the reasoning that turtle eggs were used as a food source by the island communities. At the end of the 10 years, the initial moratorium was renewed on the 1st of January 2006 and incorporated a ban on taking eggs from 14 distinct islands. It was noted that a total ban on eggs would be implemented from the 1st of January 2007. However, to date no actions have been taken to put the legislation into effect. While legislative "paper" protection for turtles exists in the Maldives, it is not monitored, nor enforced. This case study focuses on a campaign initiated by the Four Seasons Resorts of Maldives that is planned to enforce the turtle protection legislation in Baa Atoll which sits north of Male Atoll. The atoll has 13 inhabited islands and 7 resorts. The main economic activities carried out in Baa Atoll are fishing, tourism, thatch (cadjun) weaving, retail businesses, carpentry, masonry, and agriculture. As tourism is one of the major income earners for the atoll, a conflict arises from the illegal harvesting of turtles in the islands. It is planned to initiate a campaign with the theme "Sea Turtles: Protect them, Protect our heritage" to educate the school children in Grades 8, 9 and 10 (age group 14 – 16 years) on conservation of turtles. These students will then engage the younger children in the age group of 5 – 13 years to run awareness activities for adults on the islands. All 13 islands will be covered under this campaign. Activities that will be carried out include presentations on conservation and the importance of the turtle for the economy, dramatic plays on harvesting and consequences, door-to-door awareness programs and distribution of awareness materials such as leaflets and badges with the campaign logo on them. It is hoped that this pilot campaign will be replicated throughout the Maldives by similar initiatives.

*EVERYBODY LOVES A GOOD FENCE: THE RELATIONSHIP BETWEEN THE DISCOURSE ON MARINE PROTECTED AREAS AND CONTROL OVER MARINE SPACES IN ORISSA, INDIA

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Marine conservation methods and practices in India are now conspicuously similar in design to terrestrial approaches. The protection of endangered marine species and habitats such as turtle nesting and breeding areas or coral reefs has usually meant cutting off human access to certain habitats and prohibiting the trade and use (sustainable or otherwise) of these species. This paper focuses on the conservation idea of Marine Protected Areas and examines the discourse related to one such bounded space involving various actors drawn into the debate over the Gahirmatha Marine Sanctuary (GMS), on the Orissa coast. Since the 'discovery' of the seasonal olive ridley sea turtle (*Lepidochelys olivacea*) mass-nesting site at Gahirmatha in the year 1975, there has been much national and international attention focussed on the protection of these turtles. The Orissa Forest Department formally declared the GMS – an area measuring 1,435 square km. Through a final notification in 1997, the GMS was introduced as an unchallenged legacy of the State to effect conservation, by means of restricting certain rights for conservation benefits. Fishery-related turtle mortality on the Orissa coast over the last decade however, has exceeded 100,000 with 10,000 to 15,000 dead turtles washed ashore each year since 1999. The inadequacy of the GMS as a means of protecting this population of ridleys has been alluded to by biologists. Questions on injustices and negative impacts on the fishing communities living off these resources began to emerge as implementation began in some degree of

seriousness in the region over the last decade. The protests over the fishing restrictions in the sanctuary and accompanying restrictions elsewhere on the coast have snowballed into an open but complex conflict between and within the fisher communities and various conservation proponents. Neither are the battle-lines clear, nor the sides involved distinct. While there is greater diversity of views on revisions of fishing restrictions in other parts of coastal Orissa, discussions on the GMS appear restricted by the sacrosanct legacy of fenced off conservation areas. The compulsive arguments over the design of the GMS and its boundaries are continually distorted, reflecting not just a problem of representation among scientists, fisherfolk, and the State, but also a larger set of unresolved dilemmas. The heterogeneity of various actors concerned with this issue adds to the levels of difficulty in interpreting actions and perspectives. Within the rhetoric around the boundaries, clear problem areas emerge. These relate to the question of sovereignty of the fishing community; the challenges of fisheries management and community organisation in a rapidly evolving fishery and its community. A significant emerging dilemma among all actors is the uncomfortable situation of refugee / immigrant identity among the Bengali-speaking communities inhabiting the northern regions adjacent to Gahirmatha. The paper attempts to amplify how these factors, distilled through the discourse on the GMS's boundaries, influence the shaping of conservation problems, solutions and failures in Orissa.

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*TURTLE TALKS: A STUDENT CREATED OUTREACH EDUCATION PROGRAM

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At age eleven (in 2001), I created a sea turtle workshop for children. Since then, my interactive program called Turtle Talks has reached more than two hundred thousand students around the world. The program includes live workshops and an activity book. At the workshop, students bury ping pong balls in a turtle shaped sand box to replicate a mother turtle laying eggs. Then a child attendee is asked to model the homemade sea turtle costume and the anatomy of a turtle is explained, followed by a DVD that shows turtles in their natural habitat and dangers that they face. This "fun with a purpose lecture" always includes a question and answer period. Each child is given a free sea turtle activity book. A washable tattoo is handed out to each student, in the hope that it will encourage conversation with the adults in their lives. To date, more than two hundred thousand activity books have been printed and distributed around the world and translated into Spanish, French, Tamil, and Telugu. Students in more than 14 countries have received the book, including India, Cuba, Haiti, Honduras, Nicaragua, Guatemala, Panama, Gabon, Kenya, Congo, Equatorial Guinea, Australia, Cape Verde, and Mozambique. The book is used by various international conservation organizations as well, including the Smithsonian Tropical Research Institute, Oceana, WIDECAST, SEE Turtles, and others. For this work, I have won the Brower Youth Award, Blue Vision Award, Presidential Youth Environmental Award, and the Volvo For Life Award and I am currently a finalist for the Young Laureate Rolex Award. Turtle Talks is filling a niche by supplying children around the world with an engaging, free printed educational resource on sea turtles. It promotes the message to youngsters that they are the generation that needs to become advocates for these charismatic reptiles. In my presentation, I will share lessons learned from eight years of environmental education, including how to engage students with hands-on participation and develop effective written materials. This sea turtle science seminar can easily serve as a model and be adapted to engage every youth community worldwide. Thanks to those that believed in this youth created and sustained conservation program. Especially, the encouragement of Linda Soderquist, Jerris Foote, and Maran Hilgendorf. The support of Dr. Tony Tucker and Mote Marine Laboratory. To the alliance with SEE Turtles, Brad Nahill and Dr. Wallace J. Nichols. The association with the Caribbean Conservation Corporation, David Godfrey and Rocio Johnson. To the many organizations that have sponsored the publishing of the sea turtle activity books including, Charlotte Harbor National Estuary Program, Florida Fish and Wildlife Conservation Commission, and Coastal Wildlife Club.

FISHERMEN MUST PARTICIPATE IN SEA TURTLE CONSERVATION IN MYANMAR

Wanna Swe and Maung Maung Lwin

Crocodile Farm and Marine Turtle Conservation Unit, Department of Fisheries, Yangon, Union of Myanmar

Sea turtles are recognized as one of the most seriously endangered species in the world. They are incidentally caught and injured during fishing activities. Large-scale turtle mortality is the result of incidental catch in fishing gears. For sea turtle conservation, research and training are essential to increase sea turtle populations, which are one of the biological resources. There are cases of marine turtles being incidentally caught and injured during the fishing season and cases of killing and consuming of marine turtles which come to take shelter because of adverse weather conditions. Fishermen need to be widely educated and informed for the conservation and protection of sea turtles. The Department of Fisheries (DoF) is educating fishermen and the public living in coastal areas on the conservation and protection of marine turtles. The DoF has experienced difficulties in getting feedback from fishing vessels and fishing villages regarding the marine turtles. As preservation of sea turtles in Myanmar waters and their prosperity depends on the interest and participation of local people and fishermen, education programs have been initiated targeting the fishing communities and the local people along the coastline. Department of Fisheries has also prohibited the use of fishing gears which have harmful effects on sea turtles and adoption of these measures is being encouraged. It is important that fishery workers invented and learn to use a type of fishing gear which will be effective in catching fish but harmless to turtles. One of the main factors which can cause a decrease in a population of sea turtles is fishing activities in the sea, which indicates the importance of involving the coastal residents and fishermen to cooperate in conservation activities that can add to understanding of sea turtles. Conservation activities such as protection from human disturbance, illegal harvest and hunting were conducted by Ministry of Livestock and Fisheries as preservation of sea turtles in Myanmar waters and their prosperity depends on the interest and the participation of local people and fishermen. In this paper, fishing activities, education and awareness, and conservation activities in Myanmar are also described and discussed.

*TURTLE CONSERVATION ON THE COAST OF CHENNAI, TAMIL NADU

Arun V, Adhith Swaminathan, Akila Balu, Divya Karnad, and J. Subramanean

Students' Sea Turtle Conservation Network, Chennai, Tamil Nadu, India

The Students' Sea Turtle Conservation Network (SSTCN) has a few USPs. It is a non funded voluntary group working on turtle conservation for 21 years, working in an urban context by using turtle conservation as a platform to raise awareness about environmental issues and making it possible for people who want to get involved in conservation work to actually do so. Every year, we work with a team of about 20 to 30 volunteers who are mainly from colleges, a few from schools and recently some from IT companies. Many of these volunteers just last a season or two. There is therefore a huge turnover of volunteers. As such, over 20 years we have worked with hundreds of youngsters. This experience and exposure often touches them and inspires them to take up conservation studies or activities and to live life a little more sensitive to the environment. Turtle walks have been a popular activity in Chennai for more than two decades. We do not advertise or market our walks in any way but still get more numbers than we can handle every weekend and numerous calls asking about the walks even in off seasons. Students take up projects based on our work – for example, students from the Asian College of journalism, students taking up conservation studies in various universities, students in film institutes, students from abroad who come on exchange programs, etc. As an organisation working for over two decades in turtle conservation, we have accumulated vital information regarding hatching success over this entire period, nesting over this period, habitat changes over this period as well as changes in the pattern, timing and period of nesting. We also have a record of the challenges faced in hatchery maintenance and management. Being part of an urban landscape, the threats faced by turtles are innumerable and ever growing. The expanding, growing city is shrinking the habitat of the nesting turtle as construction takes place on the beach sands even up to 50 m from the HTL. With safety as a reason, high mast lights are being added all the time leaving no stretch of beach dark. Garbage, industrial effluents, and sewage destroy whatever is left. Yet, our turtles return year after year and nest right on garbage piles, in sewage sodden sand, among dense *Ipomoea* (the roots of which often damage nests), and along effluent streams. As our work is done with volunteers, we don't incur much expenditure. We use local material like bamboo and/or *Casuarina* and reuse the same for 5 years. The little money that we need is given by friends and well-wishers. Other than being free of any

pressure to raise funds, we serve as an example of a successful model to do conservation work on a small scale with the critical ingredients of passion, good will and little else.

APPROACHING SEA TURTLE CONSERVATION CREATIVELY THROUGH EDUCATION AND PUBLIC AWARENESS

Lily Venizelos and Jenny Ioannou

MEDASSET, The Mediterranean Association to Save the Sea Turtles, Athens, Greece

Although environmental education has been established since the late 1980s in Greece, it still has not become a part of the education system's curriculum and training provided to educators has been lacking. Therefore, it is essential for environmental NGOs to engage in activities targeted at schools, youth institutions and the general public, to help increase environmental consciousness. MEDASSET's creative learning and awareness raising 'Niretta the *Caretta*' project was launched in 2008. The overall vision of the project is to approach sea turtle conservation in Greece with creativity and innovation. Our "Niretta the *Caretta*" sea turtle mascot is effective in conveying environmental education messages in its immediacy and appeal. A range of pedagogical learning tools are combined to create an environment which facilitates the process of learning and relates the value of coexistence of all species to the children. Since its launch, the programme has been carried out in many private and public schools, visiting thousands of children. Its success is also due to the successful collaborations forged with several pedagogical institutions, which have resulted in the enrichment of its activities. It received the "Mediterranean Honorific Award" at a celebration that took place in Spain, on the basis of viability, originality, planning and social interest. "Return to Origin" was created in 2008 through the use of 2D and 3D computer animation to serve as a television Public Service Announcement and to target audiences of all ages in Greece and Cyprus. Its powerful environmental message is communicated through high aesthetics and depicts the devastating effects human behaviour has on our planet and the challenges humanity faces to preserve life on earth, in just 30 seconds! In 2008 and 2009 it aired on television stations in both countries. In 2009, sponsored by the Turkish Ministry of Environment, it was translated into Turkish and aired on TV stations throughout this country. The animation stars a sea turtle that takes us on its life's journey, showing the perils it faces on its marine and terrestrial ventures: coastal development, fisheries interaction, boat collision, intentional predation and pollution are taking a toll on this charismatic inhabitant of our seas and oceans. To celebrate World Turtle Day 2009, the Greek company Tram S.A. launched the screening of MEDASSET's short animated spot "Return to Origin" on its vehicles in Athens. The spot was viewed by approximately 65,000 passengers daily for a period of two months. In order to assess the level of awareness about the loss of biodiversity among Greek citizens, an electronic survey was conducted between September and December 2009. A communications sponsor, "GEO" International magazine, helped to raise awareness urging the public to participate in this effort and respond to the survey. The results will be published in the January issue of the Greek edition of "GEO", to signal the start of 2010, the Year of Biodiversity.

PUBLIC AWARENESS AND KNOWLEDGE BUILDING ACTIONS FOR SEA TURTLE CONSERVATION FROM ILLEGAL CATCH AND TRADE IN HAINAN PROVINCE, CHINA

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China's Hainan Province is not only one of the most important destinations in the south China Sea for migrating sea turtle species, including the loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and leatherback (*Dermochelys coriacea*), but it is also the illegal trading center of sea turtle products in China. That is to say, besides incidental capture in intensive fisheries, a number of sea turtles are captured for fresh meat, taxidermy specimens, bekko-made items and even pets for purchase. These are major causes for the dramatic decline of sea turtle numbers in the past 50 years in China. This may partially stem from the low awareness regarding the plight and status of sea turtles among visitors and local communities, especially fishermen. In light of this, we initiated a public awareness and knowledge building programme in Hainan Province, focusing on Haikou – the capital city of Hainan Province. During the three-month-

long campaign, our team distributed more than 1,000 copies of pamphlets and 150 SWOT (the state of the world's sea turtles) reports, explaining the basic biology, status and conservation needs of sea turtles, as well as seeking public support in reporting illegal trading and rehabilitation. Particularly targeted people included tourists, fishermen in fishing harbors, sellers in the markets vending turtles and tortoises and local fishery enforcement, aiming at reducing sea turtle consumption and promoting enforcement activities in sea turtle illegal trading. Our team also further cooperated with a local non-governmental sea turtle rescuing and rehabilitation organization to track the wellbeing of rescued sea turtles.

THE FLORIDA HAWKSBILL PROJECT: A FIVE YEAR SUMMARY

Lawrence D. Wood

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The Florida Hawksbill Project was established in early 2004 to begin documenting the hawksbills of South Florida, with a focus on an aggregation found on the barrier reefs of Palm Beach County. An ongoing partnership was developed with a commercial dive operation for logistical support, and local dive enthusiasts have been recruited to provide relevant sighting, location, and/or behavioral data. Numerous students, interns, and volunteers have been involved in the project, and educational programming has been developed to promote the conservation of Florida's sea turtles and coral reefs. To date, 171 hand captures of 138 individuals have occurred while using SCUBA. The turtles were retained on a vessel for the collection of morphometric data, tag placement, photographs, and sampling. The abundance, gender, origins, movements, foraging behavior, growth patterns, epibionts, and threats have been examined for this aggregation. Though the work is ongoing, we can conclude that a robust, female-biased aggregation of juvenile and sub-adult hawksbills representing numerous Caribbean haplotypes reside in the Palm Beach area year-round, feed selectively on poriferans and anthozoans, and can serve as effective ambassadors for coral reef conservation.

ENVIRONMENTAL IMPACTS

VARIATION OF HEAVY METALS LEVELS (CU, PB AND HG) PRESENT IN GREEN SEA TURTLES FROM NORTHERN CHILE, ACCORDING TO HABITAT QUALITY, AGE AND BODY CONDITION

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The present study assesses the levels of copper (Cu), lead (Pb) and mercury (Hg) present in the blood of 19 specimens of green sea turtle (*Chelonia mydas*), of which 68.4% were juveniles and 31.6% were adults. All the adults were female. Turtles were captured in two congregation sites with different levels of human intervention, located on the II region of Chile: Caleta Constitución, an area with minimum anthropic impact on the marine coast ecosystem and Terminal Pesquero de Antofagasta, located in downtown Antofagasta, where industrial and portuary activity is of great importance. Levels of the three different metals were compared between localities and also between age groups (juveniles and adults). They were also related to body condition index, which was calculated for each individual by means of the ratio between the body weight in grams (PC) and the straight carapace length in centimeters (SCL n-t), according to the formula PC / (SCL n-t)³. The information was analyzed by means of the Student's t-test and Pearson correlation coefficient, both with a 95% confidence interval. Detectable levels of the three metals were found in the blood of the all turtles. Cu total average was 2.8 µg/g. For this element, no significant differences between localities or age groups were evident. Pb average was 0.7 µg/g and Hg average was 0.07 µg/g. In both cases, significant differences were found between localities, Pb being higher in Caleta Constitución and Hg higher in Terminal Pesquero de Antofagasta. However, no significant differences were present between age groups for both metals. No relationship was evident between body condition index (IC) and the metal levels evaluated. Green sea turtles in this study displayed significantly higher Cu, Pb and Hg levels relative to those documented in other parts of the world, indicating that risks associated to these metals are higher in the II region of Chile in comparison to other areas of study.

EVALUATION OF THE ANTHROPOGENIC IMPACTS ON THE SEA TURTLES IN THE COASTAL ZONE OF THE SAN IGNACIO- MACAPULE- NAVACHISTE LAGOON SYSTEM

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Anthropogenic activities have modified relative abundance and distribution of species and affected ecosystems on a worldwide scale. Marine and coastal ecosystems are known to be highly susceptible to anthropogenic change. Sea turtles require these marine and coastal zones for nesting, foraging, development and migratory routes. Sinaloa holds five species of sea turtles in its waters, where the south coastal zone is used for nesting and the north zone for foraging. San Ignacio-Navachiste-Macapule Lagoon System (SNM), Guasave, Sinaloa is a foraging habitat where all five sea turtles species are affected by anthropogenic activities (direct fishing, fishing bycatch, consumption, pollution, and boat strikes among other threats). All sea turtle species are cataloged with some category of risk of extinction – therefore the need to study human impacts in critical foraging zones and key habitats for sea turtle conservation. We developed a systematic sea turtle stranding survey on a monthly basis to evaluate the effect of these impacts. Stranding data from February 2008 to January 2009 will be presented, where 102 stranding events were registered in 15 monitoring surveys. Most strandings occurred from July to September, with *Lepidochelys olivacea* (97%), *Chelonia mydas*, (2%) and *Eretmochelys imbricata* (1%). These months coincide with the closing of the shrimp fisheries season and related to alternative capture of other species like sharks, rays and other fish species using long-line nets (Chinchorros). We performed 27 necropsies and possible causes of dead were determined including long-line nets bycatch (65%), trauma (31%) and harpoon injuries (4%). We were not able to

determine if turtles ingested plastic or other synthetic materials. The gender was determined in 26 turtles (62% females and 38% males). The distribution of frequencies of curved carapace length (CCL) (mean = 82 cm, range 17–97.5 cm) indicates the presence of adult and immature turtles for *L. olivacea* and *C. mydas*, and immature individuals for *E. imbricata*. Sea turtle physical condition was recorded in 98% and 2% of dead and alive organisms respectively, most of them presenting a high degree of decomposition with evidence of advanced autolysis severely limiting our field work. The results partly demonstrate that sea turtle populations are being affected by human activities like fishing (both direct and incidental catch). However, further studies including histopathological, bacteriological and toxicological analysis are warranted to prove cause and effect. Stranding surveys represent an important tool to determine cause of death and obtain estimates of mortality in sea turtles. Acknowledgements: the authors would like to thank the Wildlife Trust, IPN and the Travel Awards Committee.

*PHENOLOGY OF NESTING AND THE PREDICTION OF SEX RATIOS

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Predicting the impact of climate change on animal populations is critical for conservation planning. For species with temperature-dependent sex determination the predicted rise in temperature, due to climate change, will skew offspring sex ratios unless species are able to adapt. Here we use predictions from global climate models to describe the likely impacts of rising temperature on offspring production and sex ratios of loggerhead turtles (*Caretta caretta*) at our long-term study site in Cyprus, where highly skewed sex ratios are already observed. We describe the relationship between air and/or sea surface temperature and clutch temperature and predict future sex ratios of offspring. We examine the phenological shift of nesting in this population over the past 17 years and model the temporal shift required to compensate for predicted temperature increases in this region.

ANTHROPOGENIC MATERIALS EXPELLED BY *CARETTA CARETTA* AS AN INDICATOR OF HUMAN ENVIRONMENTAL IMPACTS

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The connection that sea turtles represent between land and sea, with their migrations, put these animals at risk from the constant presence of anthropogenic garbage that humans produce. Turtles mistake inorganic materials for food, with dangerous consequence of diseases and death. In the WWF Sea Turtle Rescue Centre of Lampedusa, from 2005 to 2009 we have observed defecations of 400 hospitalized animals. Almost 300 turtles have expelled inorganic materials, which have been listed according to their origin. We have paid special attention to materials correlated with human activities, in particular on plastics. We investigated evidence of anthropogenic manipulation of the sea turtle environment and the frequency of material occurrence in turtles. We distinguished plastics according to their dimensions (small, medium and large size), colour and hardness and we correlated them to the animal dimensions and season of recovery. Our preliminary study highlighted the period occurring to excrete plastic for turtles, showing a strong and dangerous interaction between animals and materials unloaded in the seas, which increased during the analyzed period. From these results, we consider it could be interesting to improve an international context, considering the peculiarity of the Mediterranean Sea. Projects shared between international partners could give the index of impact of anthropogenic garbage on endangered sea species. We would intend to investigate short, middle and long term impact in health state of sea turtles.

*VULNERABILITY OF SEA TURTLE NESTING GROUNDS TO CLIMATE CHANGE

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Sea turtles are thought to be particularly vulnerable to climate change since they have life history, physiology and behavioural traits that make them extremely sensitive to climate change. The most direct impacts of climate change on sea turtles will likely occur on their terrestrial reproductive phase (egg laying, egg incubation and hatchling success phase) since there are clear and relatively straightforward effects of increased temperature, sea level rise and cyclonic activity on sea turtle nesting sites and reproductive output. Given sea turtles' potential vulnerability to climatic changes and the future scenarios of global warming there has been recent concern over the potential impacts and implications of climate change on them. Thus, there are a growing number of studies investigating and predicting how climatic processes will affect sea turtles and their nesting grounds. Most of these studies predict how increased sand temperature or sea level rise will impact sea turtles and their nesting grounds. Although these studies provide valuable information and insights into how each climatic process can or will impact sea turtles at an ecological scale they are limited because processes are likely to occur simultaneously and cause cumulative and synergistic effects. Additionally, most of the studies conducted to date only focus on one nesting ground for a particular turtle population. Such an approach does not provide a full understanding of how a population, (management unit) will be affected. Consequently, there is the need of a methodological approach that investigates how multiple climatic processes will impact the full range of nesting grounds used by a turtle population. Therefore, we used a vulnerability assessment framework to assess the cumulative impact of various climatic processes (sea level rise, increased temperature and cyclonic activity) to the main nesting grounds used by the northern Great Barrier Reef green turtle population. Our study indicates that in the short-term (by 2030) sea level rise will cause the most impact to the nesting grounds used by the northern Great Barrier Reef (nGBR) green turtle population. Therefore, in the short-term, reducing the threats from sea level rise may provide a greater return in conservation investment than mitigating the impacts from other climatic processes. Indeed, our results indicate that if the impacts from sea level rise are mitigated the vulnerability values of almost all rookeries will be reduced to low levels. However, in the longer-term by 2070, sand temperatures will reach temperatures above the upper transient range and the upper thermal threshold and cause relatively more impact to the nGBR green turtle population. Thus, in the long-term, a reduction of impacts from sea level rise may not be sufficient, as rookeries will start to experience high vulnerability values from increased temperature. Our method provides the first systematic and comprehensive framework to assess how sea turtle nesting grounds will be affected by multiple climatic processes. The framework used here can easily be adapted if new information is obtained and can be transferable to different sea turtle populations and sea turtle life cycle phases provided the necessary data exists.

*DHAMRA – TA-TA TO TURTLES?

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The paper is a case study of the Dhamra Port, coming up along the east coast of India, in Orissa, and the concern raised by several non-governmental organisations and non-government institutions about the possible impact that the port may have on turtles and turtle migration off the east coast of India. The paper will look at the manner in which the port was given environmental clearance, the inadequacies and shortcomings of the EIA report that was prepared, and list some of the efforts made to persuade the Tatas to withdraw from this project. The current status of the project and the latest developments in the Supreme Court of India will also be discussed. The role of the Governments (State and Central), the role of the Forest Department and the Ministry of Environment and Forests of the Government of India, and the role of the Judiciary will be discussed in some detail. The author will also discuss some of the pros and cons of the judicial process in India with reference to environmental issues. The author will offer insights in the decision making process based on his experience in this field over the past 30+ years.

*ENVIRONMENTAL RESEARCH ROBOTS – DATA COLLECTORS FOR THE HAWKSBILL TURTLE

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"The Save the Turtle" project, a research endeavor by the College of the North Atlantic-Qatar, is an innovative melding of technology, education and the environment. Autonomous environmental research robots are being designed and programmed to help protect the critically endangered hawksbill turtle in Ras Laffan Industrial City, Qatar, by collecting data from a list of potential parameters which may include sound levels, light levels, temperature, turtle numbers and turtle movements. We believe that robotic technology exhibits the best pedagogical theories involving hands-on learning, systems thinking, problem solving and modeling. Our main impetus is to supply opportunities for undergraduate students from the College of the North Atlantic-Qatar to be involved in environmental research issues employing robotic technology. The multidisciplinary team has applied classroom theory in a research setting using computer programming, environmental science, statistics, physics, mechanical and electronic engineering. This paper will describe in detail the missions undertaken by the environmental research robots and the challenges inherent to them and the turtles in the harsh desert and industrial environments. The ultimate goal is to customize fully functioning non-intrusive robots for environmental monitoring wherever statistics can enhance or protect nature.

HEAVY METALS IN SEA TURTLES FROM THE NORTHWEST MEXICO

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Five species of sea turtles, *Dermochelys coriacea*, *Caretta caretta*, *Lepidochelys olivacea*, *Eretmochelys imbricata* and *Chelonia mydas agasiizzi* have been documented in Northwest Mexico. This region has been recognized as priority for the protection of nesting and developmental habitats for these species. The major threats for sea turtles include direct fishing and consumption by local communities, fisheries bycatch, egg harvest from nests and habitat destruction. Pollution of the oceanic environments induced by humans represents a further threat to sea turtles and other species through bioaccumulation, bioconcentration and biomagnification of contaminants. Bacterial metabolic pathways in a short time cannot degrade heavy metals persisting in the environment for long periods of time potentially harming the health of organisms and ecosystems. Sea turtles may provide an early warning system or be sentinel species with specific biological characteristics that provide information about the health of marine ecosystems. The purpose of this study is to determine the reference levels of heavy metals (Zn, Ni, Mn, Cu, Se, Pb, Cd and Hg) in four species of sea turtles from Northwest Mexico. We collected blood from June to December 2008 in different foraging areas of Northwest Mexico with the support of Grupo Tortuguero for validation and analysis based on earlier studies. Heavy metal concentration analysis in blood was performed with a Plasma Atomic Emission Spectrophotometer (ICP-OES). We collected specimens from 59 sea turtles distributed as follows: *C. caretta* (n=22), *L. olivacea* (n=17), *C.m. agassizii* (n=15), *E. imbricata* (n=5). Straight carapace lengths averaged (64.02 cm) and this was not statistically significant (P = 0.30) among species. Turtle tissues that presented major average concentration of As (6,121 μg g^{-1}) and Cd (1,014 μg g^{-1}) were detected in *C. caretta*. Pb and Hg were below limit of detection. Essential heavy metals (Zn, Cu, Ni and Mn), Zn was found in major average concentrations in *E. imbricata* (66,609 mg Kg^{-1}). Ni (2,176 μg g^{-1}) and the Mn (2,478 μg g^{-1}) in *L. olivacea*. Finally, Cu was in higher concentrations in *C. caretta* (2,528 mg Kg^{-1}). The average concentrations followed this order: Zn > Se > Ni > As > Cu > Mn > Cd. Acknowledgements: the authors would like to thank the Wildlife Trust, IPN and the Travel Awards Committee.

OLIVE RIDLEY TURTLE (*LEPIDOCHELYS OLIVACEA*) PREDATION BY COYOTES (*CANIS LATRANS*) IN CEUTA BEACH, SINALOA, MEXICO

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In all their development phases, marine turtles, due to their wide geographical distribution, habitat and biological characteristics, are highly vulnerable to wild animal predation. The aim of this study is to provide information about *L. olivacea* predation rate by coyotes in Ceuta beach. This includes a count of looted nests and predated turtles and analysis of coyote faeces. Turtle predation by coyotes has decreased from 1992 to 2009 but these data are not statistically significant. This result might be caused by a decrease in the coyote population or the improvement in conservation strategies.

RELATIONSHIP AMONG TIDES, BEACH PROFILE AND NEST SUCCESS OF LOGGERHEADS IN SAL ISLAND (CAPE VERDE)

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During the incubation period of about 60 days, sea turtle eggs are potentially subjected to the harmful effects of sand erosion, progress of the beach and tidal excursions. Laboratory and field studies have demonstrated that not only can these natural phenomena directly destroy a large number of nests but also can lead to sea flooding, another important threat to the safety of the nests. Previous studies have shown that the hatching success depends on the duration of the flooding: the hatching percentage progressively declines if the eggs are submerged for a few days as the physiological process are permanently damaged during the immersion in the water. During long flooding the development of the embryos stop with consequent increase of unhatched eggs. The main purpose of this study was to determine the relationship between the tidal excursion and the slope of the beach and to understand how this relationship can influence hatching success in loggerhead (*Caretta caretta*) nests. In order to create a beach profile, 29 transects were used to study an area of a major nesting beach (Algodoeiro) in Sal Island, Cape Verde. A georeferenced 3D map was then created with altitude iso-lines from the zero sea level. Three typologies of nests were studied: in situ nests without any kind of manipulation, trans situ nests moved to a new position in the same beach farther away from the tide influence, and nests which were moved into a hatchery located on another beach. For each nest (including the translocated ones) the GPS position was marked and introduced in the map to study its location regarding the beach profile, and the percentages of hatching success and emergence success were recorded. These assessments are expected to provide valuable information for the management of turtle conservation programs in Sal Island, for instance by identifying which beach sectors are more exposed to flooding danger. In this way, SOS Tartarugas rangers that will patrol the beach next year will have a new tool for a better evaluation of the risk of leaving a nest in situ or moving it, on the basis of its position on the beach and the relationship between the beach profile and the tidal cycles.

TOURISM, COASTAL DEVELOPMENT AND FISHING ACTIVITIES ARE THE CHIEF CAUSES FOR THE EXTINCTION OF SEA TURTLES IN THE VERY NEAR FUTURE

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Sand mining, industrial pollution, building constructions at beach side, tourism hotels, sport and cultural entertainment at the beaches during nesting season. Fixing of high power lighting on the beach, experimentation by different modes of fishing at the shores. Increased fishing activities by trawlers and mechanised boats, hatcheries along the coast. Expansion of beach roads towards seaward side. Setting up of industries along the shore water and release of toxic wastage into the sea water… these activities are compiled into the groups of tourism coastal development and fishing activities and are the chief hurdles facing the sea turtles on our coast. Increased human population is indirectly but definitely related and translated into developments to sustain the comforts of the human population. This is fast resulting in extinction of the sea turtles. In fact all the developments are the cause for the promotion of fatal occurrences of natural disaster like tsunamis to happen and cause a real threat to the entire environment. If we are to make an effective contribution to save, protect and conserve the most important link of the oceanic life cycle – the sea turtles – then these "two main predators" must be addressed most immediately. This is our main emphasis that is included in our schedule of protecting the sea turtles at our location.

PHYSICAL AND CHEMICAL COMPOSITION CHANGE OF GREEN TURTLE (*CHELONIA MYDAS*) EGGSHELLS DURING EMBRYONIC DEVELOPMENT

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In this study, the chemical elements and physical characteristics, namely weight and diameter, of green turtle (*Chelonia mydas*) eggshells collected from Samandağ Beaches (Turkey) were studied to characterize differences between the composition of their chemical elements and changes in physical parameters. Eggshells belonging to different growth stages from the 1st to 4th developmental stage (24 for each) that yielded successfully hatched eggs (total 31), that had infertile eggs (total 25) and that included deformed/parasite-infested/abnormal eggs (total 15) were examined to determine any changes that had occurred in the eggshells during embryonic development. According to Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), calcium and strontium concentrations in the eggshells decreased approximately 70% during embryonic growth, particularly during the 3rd and 4th growth phases. Moreover, zinc concentration declined almost 60% overall. Copper and magnesium concentrations increased throughout the developmental stages indicating that the eggshell is a protective medium for the developing embryo that does not allow some toxic elements to pass through.

*A NEW WAY TO MEASURE LIGHT – THE TURTLE SKY CAM

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The impact of light on hatchling turtles has been recognised since 1911 when Hooker first documented phototaxis in *Caretta caretta*, and now, almost 100 years on, it is generally accepted that both intensity and wavelength are important factors influencing hatchling behaviour. Since the early 1900s, attempts to find a simple, sensitive and reproducible instrumental method to quantify light across the entire visible spectrum has challenged researchers worldwide. Commercial instrument types typically used to quantify light include illuminance (lux) meter, spectroradiometer, luminance meter, stellar photometer and sky quality meter. The application of these instruments in sea turtle research is limited by various combinations of poor detector sensitivities, measurement of a restricted range of wavelengths (e.g. CIE curve wavelengths only), an inability to regularly and confidently target specific light sources and the fact that the different instruments use different units of measurement which cannot be used to

standardise light measurements for cross instrument comparisons. Not only do these limitations restrict our ability to compare the biological results from field and laboratory experiments with hatchling marine turtles but they also prevent us from obtaining reliable baseline light data for the use in regulatory agency management of anthropogenic light pollution worldwide. We present here a potential solution to the problems of reliably measuring light accurately and precisely. Using existing charge-coupled device (CCD) technology used for astrophotography we have modified an newly developed version of an SBIG All Sky Camera so that the incoming radiation is filtered to allow transmission of light in the blue region of the spectrum only (400 – 500 nm). The camera is powered independently so that it can be deployed in remote locations and is linked to a standalone laptop computer which collects and stores the digital images for subsequent processing. The prototype camera is being deployed at Barrow Island in November 2009 for proof of concept field trials under full moon and new moon conditions and to collect baseline data prior to the commencement of construction of the Gorgon gas plant, the largest LNG processing plant to ever be built in Australia. The results of these trials will be presented here.

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*PREDICTING THE EFFECTS OF CLIMATE CHANGE ON SEA TURTLE NESTING HABITAT IN FLORIDA

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Climate change poses a significant threat to species that are sensitive to temperature. Sea turtles exhibit temperature-dependent sex determination and seasonal migration patterns and it has been hypothesized that predicted climatic changes could influence nesting behavior. Currently, three species of sea turtles, *Chelonia mydas*, *Dermochelys coriacea*, and *Caretta caretta,* nest extensively on the beaches of Florida. Most *C. mydas* nesting in Florida occurs along the southeast coast, although nesting has been observed in almost every coastal county. *D. coriacea* nesting in Florida also occurs almost exclusively on the east coast, particularly in the area around Palm Beach County. *C. caretta* nesting in Florida occurs mostly on the east coast as well, and accounts for about 90% of all *C. caretta* nesting in the U.S. While Florida nesting counts of *C. mydas* and *D. coriacea* have shown an increasing trend over the past twenty years, *C. caretta* nesting has experienced a long-term declining trend over the past decade. I evaluated the impact of changing climate conditions over the next fifty years on the availability of sea turtle nesting habitat in Florida given predicted changes in temperature and precipitation. Environmental and climate variables likely to affect sea turtle nesting habitat, including elevation, solar exposure, temperature, and precipitation, were built into a maximum entropy (Maxent) model to predict the distribution of sea turtle nesting habitat under current conditions. The model results closely matched current nesting distributions for all three species, with a slight overprediction of potential nesting habitat. The model was then projected using a future climate (as predicted by the Intergovernmental Panel on Climate Change A2 scenario) to predict the potential distribution of sea turtle nesting habitat under climate change. Initial projection model results indicated a decline in nesting potential and have led me to explore which of the environmental and climatic variables are driving the predicted reduction in available nesting habitat, particularly since inundation has not yet been included in the model. While sea turtles are resilient and may adapt to use new locations for nesting, it is possible that climate change will devastate sea turtle populations through reduced nesting potential. Therefore, scientists must closely observe nesting sea turtle populations, both in Florida and worldwide, as nest distribution may change significantly in the next few decades. In addition, knowledge of the factors that influence nesting habitat suitability may inform coastal managers who seek to restore/create beaches to provide suitable nesting habitat. Further research is needed to incorporate potential sea level rise into the models, and increased availability of higher-resolution climatic variables would allow more localized analysis of habitat suitability.

MODELLING THE STATISTICAL POWER TO DETECT PILE DRIVING INDUCED VIBRATIONAL MORTALITY ON SEA TURTLE EGGS

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Port development around the globe is increasing with many ports positioned near marine turtle nesting grounds. The impact of port construction on critical life stages of sea turtles such as nesting females and embryonic development is still poorly understood. Pile driving management plans are lacking data on the impact of vibration on embryogenesis and hatchling vigor. The aim of this study is to model the impact of vibrations on embryonic development to identify stages where impact is detectable. The flatback sea turtle, *Natator depressus*, is an excellent model species for this study. The sea turtle research program at Bare Sand Island, Australia, forms a baseline of nesting and hatching success data extending to the late 1980s. This information includes recorded nesting history of individual adults and hatching success for approximately 50% of the nests at Bare Sand Island every year. The experimental design includes three stages of embryonic development, each of which is treated with six vibrations of varying frequency and amplitude with an additional non-vibrated control. To achieve high analytical power in this project, a simulation conducted under different scenarios of linear and non-linear impacts examines the sensitivity of the experimental design. This analysis reveals the sample size and numbers of replicas needed to achieve the 91 ± 6 % natural hatching success with 90% power for the tested stages of embryonic development. This combination of frequency and amplitude needed to produce the lethal vibration (LV50) may be extrapolated to produce the LV 09 above which increased mortality may be attributable to vibrations from pile driving. Safe approach distances of pile driving to nesting beaches are produced by incorporating the lethal vibration values into the impact zone models for port development.

*DISPERSAL PATTERN OF GREEN TURTLE (*CHELONIA MYDAS*) HATCHLINGS AT SEA FROM A NESTING BEACH NEAR A PETROCHEMICAL COMPLEX IN TERENGGANU, PENINSULAR MALAYSIA

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After emerging from underground nests, turtle hatchlings are known to use light sources and surface waves for guidance towards the open sea. Apart from natural predation, artificial light sources may also contribute to hatchling mortality, in part due to disorientation from their natural magnetic compass direction; this has important conservation implications. In order to investigate the effects of artificial light sources from a nearby petrochemical complex on the orientation of green turtle (*Chelonia mydas*) hatchlings, we studied the dispersal patterns of 73 green turtle hatchlings from Ma' Daerah Beach in the state of Terengganu, on the east coast of Peninsular Malaysia. Lighted floats were attached to the hatchlings and they were monitored from a distance by kayaks for 60 minutes with GPS readings taken every five minutes to establish their offshore directions. Our results showed that almost all hatchlings swam either perpendicular to the beach or into the approaching wave's direction coming from SE. Most hatchlings, however, orientated themselves in a NNE direction after 60 minutes, possibly due to the influence of waves and currents. However, circular statistics (i.e., Rayleigh test and V-test) revealed that the hatchlings' dispersal patterns were random. On the nights when ships were present, the hatchlings had a larger swimming dispersal angle compared to the moonlit nights and hatchlings appeared to swim towards the reflection of the moon on full moon nights. As our findings are preliminary, more trials will be conducted to increase the sample size over a longer period of time in order to elucidate the effects of artificial light sources on green turtle hatchling dispersal patterns.

*EFFECTS OF ECOLOGICAL FACTORS ON NESTING AND PHYSIOLOGY OF THE INDIAN SOFT-SHELLED TURTLE –IMPLICATION IN CONSERVATION BIOLOGY

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The Indian soft-shelled turtle, *Lissemys punctata punctata,* is facing an acute biodiversity crisis due to the interaction of different natural and anthropogenic factors. Detailed nesting activities of this turtle have been studied in both natural and artificial habitats for the last several years. In both cases, gravid female turtles were found to emerge out of water to locate suitable nesting sites, preferably on sloping banks or nearby land. Nesting commenced during late August to September through digging of an L-shaped tunnel by the females by scraping soil with both of their hind legs used alternately. Before returning to ponds, females filled the nests with the scraped-out soil. Turtles that completed nesting, laying and covering the nests before returning to ponds were referred to as normal layers, whereas those emerged out of water, moved to and fro for suitable nesting sites but could not build a nest and either oviposited on land without nesting or returned to ponds to oviposit in water were called disturbed layers. Blood samples were collected from the leg vein of turtles immediately after capture from nesting sites at different phases like 'emerged out of water for searching nesting sites', 'digging nests', 'completed nesting and laying' and' disturbed layers'. Reproductive hormones like estradiol-17β and progesterone and stress hormones like corticosterone, epinephrine and norepinephrine were assayed from collected blood samples. In artificial ponds, nesting and hatching success were 88%, but in natural ponds, these were less than 5%. The main ecological factors affecting nesting and hatching in natural ponds were identified as (i) abiotic factors like heavy and untimely rainfall, flood and soil erosion causing prevention or destruction of nest, and (ii) biotic factors in the form of predation by avian or mammalian predators that caused destruction of fresh nests and eggs therein. The disturbed layers were found to lay within 2–3 days on open muddy land or even in water. These eggs were mostly devoured by different predators and never hatched. Plasma estrogen and progesterone showed no significant changes among the normal and the disturbed layers in any phase of nesting. Estrogen peaked in the sluggish gravid females which were about to emerge out of water for nesting. Progesterone peaked in the post-laying turtles as well as those failed to nest in 1 or 2 days after emergence. However, corticosterone showed significant difference ($p \leq 0.005$), being much higher in the disturbed layers than in the normal post-layers. Epinephrine and norepinephrine showed no significant difference between two groups during nesting. This study predicted that nest site selection, nest building and oviposition are most vulnerable to biotic factors. Furthermore, physiological stress as evidenced from high corticosterone level is associated with nest site degradation and consequent abnormal oviposition. All these persistent stressors adversely affect survivorship, population structure and thereby conservation of *Lissemys* turtles.

OLIVE RIDLEY SEA TURTLES MAY BE EXTINCT IN TEN YEARS IN ORISSA

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Mass-killing of endangered olive ridley sea turtles coupled with beach erosion and the construction of ports and fishing harbours will pave the way for the extinction of sea turtles within a decade in Orissa, an eastern State of India. The turtles, which migrate to the three major nesting sites at Gahiramatha beach, Rushikulya and Devi river mouth areas of the State each winter get trapped in fishermen's nets or fall prey to developmental activities along the shoreline. The decision of the government to construct about six ports in the state including a port at Barunei river mouth within Bhitarkanika National Park and Gahirmath Marine Sanctuary would invite more danger to the turtles. The government has already started construction work of a port at Dhamara near the Bhitarkanika National Park despite strong opposition from many environmentalists. The construction of many ports near the sea without proper scientific study will be a disaster for the coastal people, as the areas will be affected with sea erosion after the construction of ports. Until the 1980s, nearly half a million turtles were laying eggs on 25 km long beach at Gahiramatha beach but now due to beach erosion the turtles nest only at two tiny (1.5 km long) islands, Nasi-1 and Nasi-2, near Gahiramatha. The 25 km long Gahiramtha beach, the world's largest rookery of the endangered marine

species, has also faced major obstacles due to changing pattern of the beach. The elongated sandy beach which was extended into the sea in the north of Eakakula in Gahirmatha has been broken into several spits during the last cyclone. Therefore the higher rate of congregation of the olive ridleys has been shifted to two tiny islands, Nasi-1 and Nasi-11. The rampant sea erosion at Gahiramatha, including Nasi-I and Nasi-11, has been occurring rapidly and as a result nesting areas have been reduced to only 1.5 km this year, during which the turtles are not finding more space for laying eggs.

*PORTS AND SHIPPING: SEA TURTLES AT RISK

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Where ports and shipping intersect with sea turtle nesting beaches, nearshore habitat and ocean migration paths, the potential for harm to, or disruption of, sea turtle life cycle arises. Further understanding of port and shipping pollution and operational impacts in or near sea turtle habitat is needed. Port operations and shipping have the potential to increase noise, lighting, air pollution, water pollution and other potentially negative environmental impacts. Port construction often involves dredging, deepening of channels, destruction of underwater habitat, and installation of structures disruptive to sea turtles. Ships are allowed under international law to discharge sewage, graywater, garbage, contaminated ballast water and oily water overboard into the ocean. Oil spills and illegal dumping also occur. There is a need to 1) Educate the international sea turtle community on the potential environmental impacts of ports and shipping in sea turtle habitat, 2) Provide a forum for sea turtle conservation community, shipping experts and scientists to share information about ports and shipping in sea turtle habitat, 3) Identify research gaps that need to be filled in order to understand and minimize potential impacts from ports and shipping on sea turtle conservation, 4) Establish mechanisms for on-going education and research on ports and shipping in the international sea turtle community. This paper will provide an overview of the issues, examples of port/shipping interactions with sea turtles, a reading list and a proposed plan of action for addressing risks to sea turtles from ports and shipping.

*PRELIMINARY RESULTS FOR THE POTENTIAL OF RAINFALL AS A MITIGATING FACTOR IN LIMITING BEACH FEMINIZATION OF THE PLAYA NORTE LEATHERBACK ROOKERY

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Beach feminization due to increasing global temperatures, a mounting alarm for sea turtle conservation, is of particular concern for many tropical rookeries as they typically lack seasonal temperature variation. This lack prevents a potential shift in nesting season as an adaptive solution; however, beaches that experience high levels of rainfall (a cooling factor) during the nesting season may continue to produce male hatchlings. To determine the possibility of rainfall as a cooling factor for leatherback (*Dermochelys coriacea*) nests on Playa Norte, Costa Rica, temperature data loggers were placed in nests (n=11) and temperatures experienced throughout incubation were compared to rainfall and ambient air temperatures. All nests experienced unlikely male-producing temperatures even though ambient air temperatures were very high (max = 39°C, mean = 30.02°C). Most significantly, isolated extreme rainfall events – considered as more than 50 mm of rain in a 24 hr interval (n=4) – greatly affected nest temperatures resulting in a rapid (<24 hrs) drop in all nest temperatures (temperature change: min. = 1°C, max. = 3.2°C). This rapid change in nest temperature resulting from an extreme rainfall event eliminated the typical moderation of daily fluctuation that eggs at depth usually experience. The Tortuguero Lowlands of Costa Rica experience very little seasonal variation in rainfall and thus may become a refuge for male hatchling production in future if global warming trends increase.

TURTLE CONSERVATION IN THE ARTIFICIAL REEF ZONE – PULICAT, TAMIL NADU, SOUTH INDIA

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Pulicat is the second biggest brackish water lake in India enriched with flora and fauna. The natural sandbars at the mouth and the adjacent coastal area are nesting and breeding areas for sea turtles in Pulicat. There are fifty fishing villages around Pulicat. Poaching turtle eggs and meat were a regular practice. The need for conserving sea turtles was stressed to local fishermen through periodic meetings with the villagers. Finally, poaching was effectively controlled by the local fishermen youth group. Fish aggregating devices viz., artificial reefs, were deployed in Pulicat to enhance biological resources in the coastal waters. The artificial reefs serve to promote the livelihood of local fisherfolk and also enrich the coastal ecology. The reef area became a breeding and feeding ground within six months of deployment. The shade and availability of sea plants make the fishes rest, breed and feed. Within six months, the entire artificial reef area became a seawater fish colony. Sea turtles accidentally caught in fishing gears were left in the artificial reef area. Nesting places are protected by the youth group and regular monitoring is taking place in all the villages. The eco clubs in schools spread awareness to school children on the protection of sea turtles. The poachers are identified and cautioned about the Wildlife Act. They were given alternative employment through the assistance of local NGO called PLANT and thus the poaching pressure is reduced and a sense of responsibility is created among the school children, youth, women and fishermen. The fisher women who were actively involved in selling fish caught by their families have taken additional responsibility to save the nesting areas of sea turtles. This is a kind of socio economic and ecological improvement for local fisherfolk in Pulicat. PLANT is regularly training the youth, selfhelp groups and the fishermen community on turtle conservation in collaboration with CMFRI and research institutions.

PLASTIC DEBRIS AT AN IMPORTANT SEA TURTLE FORAGING GROUND IN ALBANIA

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Surveys of foraging habitats were conducted in Drinit Bay, Albania, during a 3-year sea turtle monitoring programme (MEDASSET and Tirana University). Plastic litter was observed on all beaches around the 30 km bay; a sparsely-populated coastal zone with little infrastructure or road access. Human sewage, sediment, and anthropogenic-waste are transported into Drinit Bay via four large rivers: Bunës, Drinit, Matit and Ishmit. To determine the worst-polluted areas, quadrat-counts of debris were conducted at eleven locations around the bay. Two quadrats (10 × 10 m) were used at each sampling-site (marked with GPS); each pair of quadrats (i.e. an area 20 × 10 m) shared a randomly-selected common baseline, with one being to landwards of it, and the other to seawards; some quadrats extended into the surf-zone. Items in each quadrat were counted into categories (e.g. plastic-bottles, carrier-bags, hard plastic, organic material). Photographs were taken before cleaning began and of the total waste collected from each quadrat. The heaviest pollution was adjacent to the outflow of Ishmit River (1,595 items in the quadrat-pair) and at Godull (1,095 items); 90% of the debris was made from plastics. These were mostly manufactured plastic items: storage-containers, shoes, crash-helmets, drinks-bottles, garden-furniture, televisions, toys and a mannequin. It seems unlikely that all of this litter originated from Godull. Substantial numbers of plastic fragments, including polystyrene, were also present. The cleanest areas were Patoku barrier-island (41 items) and Ulcinj (58 items); the latter is in Montenegro on the western side of Bunës River. In Albania 98% of human sewage is untreated and usually discharged directly into rivers or ponds near to human habitation. Sewage-effluent from Tirana, Albania's Capital, is transported via the riverine system, entering Drinit Bay from River Ishmit; there is a foul odour and discoloured plume extending out to sea. Fishermen were observed net-fishing in the Ishmit river mouth. Local villagers use the Godull beaches for recreation: sunbathing and picnicking amid the widespread debris and swimming in the visibly polluted sea. The impact of pollutants upon turtles and habitats locally is less clear: >245 loggerheads and one green have been tagged since June 2008; several were recaptured intra-annually and 21

were remigrants. Sea turtles elsewhere are known to ingest plastics and other debris encountered in the marine environment. The widespread presence of marine litter in Drinit Bay, in conjunction with the omnivorous nature of *Caretta caretta* makes it likely that plastic and other debris will be consumed by these turtles. We have no facility at Patoku for keeping turtles in order to collect faecal samples, and so it has not yet been possible to determine directly if, and to what extent, marine debris impacts upon turtles during their benthic foraging in the area. Plastics are a highly-visible sign of pollution, however, the odour from Ishmit suggests that other pollutants are also present; detailed ecotoxicity analyses are required to identify contaminants and quantify the risks to human and environmental health. The findings from this, first such, study will be passed to the Albanian government.

FISHERIES & BYCATCH

ARE TRAWL GUARDS AN ALTERNATIVE TO TEDS IN MIXED-CATCH MARINE FISHERIES?

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The use of Turtle Excluder Devices (TEDs) in trawl nets is now mandatory for all countries which export shrimp caught from turtle sensitive waters. This regulation has gone well overall with both the trawl industry and turtle conservationists in all the marine environments where trawlers engage in exclusive shrimp catch. It has, however, encountered stiff opposition from the trawl industry in India where most of the trawlers harvest a mixed catch (i.e., shrimp plus fishes of any size). The anti-TED protestors point to the huge loss of fish catch caused by TEDs fitted to the trawl nets. They argue that, no matter which TED design, there is perforce a technical limit beyond which the gap between its solid bars cannot be widened enough to allow the fish of medium to large sizes to pass into the cod end of the trawl net. In 2002, the anti-TED stir by the trawl industry took a violent turn in Orissa when the Government sought to make the use of TEDs compulsory in every fishing trawler to protect olive ridley turtles visiting Gahirmatha, the world's largest rookery of the said species. Coincidentally, in the same year a unique, alternative device, called a Trawl Guard was invented by a local fisherman. Its development promised to address the trawl industry's priority of preventing fish loss and to meet the global mandate of preventing accidental turtle drowning. Unlike a TED, which is a slightly elliptical metal grid of bars fitted into the neck of the trawl net with an opening at its upper or lower end (called a TED hole) to facilitate the escape of turtles, the Trawl Guard is an inexpensive network of nylon wires, which is simply attached to the mouth of the trawl net to serve as a guard against the entry of any sizable bycatch, including turtles. Further, unlike the severely constricted scope for widening the space between the TED bars, the size of the nylon meshes of the Trawl Guard can be manipulated to a considerable degree, keeping in mind the possible size of the fish sought to be hauled in a particular area. The Trawl Guard emerged in the aftermath of the Orissa Super Cyclone of 1999 simply to safeguard trawl nets from the menace of disaster-borne debris that had piled up on the sea bottom. Since 2002, when the first Trawl Guard experiment was conducted by an NGO, two more comparative experiments involving the Orissa Government and WWF-India have been carried out. In each test, while both devices were equally effective in exiting turtles, the trawler that used the Trawl Guard had better catches of both shrimp and fish than the one that used a TED.

*IMPACT OF FISHERY RELATED ACTIVITIES ON NESTING, MORTALITY AND THE FEEDING ECOLOGY OF OLIVE RIDLEY SEA TURTLES ALONG THE EAST COAST OF ORISSA

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The possible impact of intensive fishing on breeding, congregating turtles in the Devi rookery was studied from 2007 to 2009. The relationships between fishing vessel density, offshore congregation of turtles and the number of stranded turtles were examined. The encounter rate of trawlers along a transect off the east coast of Orissa was found to be 2.32 vessels km^{-1} and 1.47 vessels km^{-1} during the 2007–08 and 2008–09 study periods, respectively. Trawling density, mortality and nesting ($R^2 = 0.58$, F = 51.7, N = 10, P = 0.8), ($R^2 = 0.011$, F = 0.106, N = 10, P = 0.7). Significantly, numbers of stranded turtles observed on the beach coincided with the peak nesting period. During the same period, the percentage trawls observed within 5 km of the shore was considerably higher during the nesting season than in other periods of the year. There is no detailed information available on the diet of breeding olive ridley turtles. To gain insight into their diets, stomach contents of stranded turtles were analyzed between 2008 and 2009 from three rookeries in Orissa: Gahirmatha, Rushikulya and Devi. Of the 182 turtles examined, only 139 turtles had food in their guts. All 139 turtles were grouped into two size classes based on their curve carapace length

(49–59 cm, 60–79 cm). Gut contents found in the turtles were identified and analyzed for different age classes to determine their food preferences. It was found that there was difference in the diets of adults and sub-adults ($F = 3.18$ df= 6, 8 $P < 0.05$).

LIVELIHOODS AND NATURAL RESOURCE MANAGEMENT – ARTISANAL FISHERIES ALONG THE COROMANDEL COAST

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We present an assessment of livelihoods of artisanal fishers in the face of resource depletion and habitat degradation. A survey of over 10,000 households in 63 artisanal fishing settlements showed that artisanal fishers remain closely associated with their traditional occupation and less than 10% of the earning members of household surveyed had diversified into non-fishing occupations. Most households tended to diversify within the fishing sector. Fishermen coped with lower catches through extending fishing effort and distances, while vendors purchased fish from additional landing sites and explored new markets. Craft owners also took up jobs as crew on larger craft or in ring seining operations. Concerns raised included use of the ring-seine which rendered the catch of individual craft insignificant and moved the marketing linkages in favour of large traders as opposed to women vendors. The encroachment of mechanised craft into artisanal fishing grounds causing damage to nets and habitat were also concerns. These issues have direct relevance to the management of fisheries resources. The ring seine has caused conflicts between artisanal fishers and mechanised craft owners. The latter, more powerful both economically and socially, have enforced repeated six month bans on the use of the ring seine through the traditional Panchayats. Ring seine catches upset the socio-economic power equations in the face of declining catches of trawling operations. The net is operated by artisanal craft and landings are often in tonnes. Regardless of the motives behind the ban, it demonstrates the authority of traditional institutions. Given the complacency of the government on marine fisheries, traditional Panchayats may well hold the key to scientific co-management of fisheries resources along this coast. Coastal habitat degradation is another set of issues confronting fishing communities. The declining health of backwater systems is directly linked with the modification of upstream water sources. Reduction in stream flows has an adverse impact on nutrient and sediment transport that results in the blockage of river mouths by sand bars such as that outside Mudusal Odai, which has stranded nearly 70 mechanised craft of 10 fishing settlements. The beach erosion occurring to the north of Pondicherry as the result of a badly designed breakwater at the mouth of the harbour is another example. This has resulted in a disruption of the littoral drifts associated with this coast and a loss of beach to the north which has most severely affected the fishing community which needs beaches for a range of activities. Unfavourable policy frameworks are the final issue discussed. A series of attempts were made in the recent past to undermine the Coastal Regulation Zone notification of 1991. Various alternatives provisions were proposed that legitimise the occupation of coastal areas by industries, large scale development projects and exclusive economic zones. Coupled with this is the total disregard for rights of fishers who have never been faced with such a range of issues and problems that undermine their existence as an artisanal community.

SEA TURTLE BYCATCH FROM SMALL SCALE ARTISANAL FISHERIES AND CONSERVATION EFFORTS ALONG LAGOS STATE COASTLINE, NIGERIA

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A survey of sea turtle bycatch from small scale artisanal fisheries was conducted in 2008 in some fishing communities or villages along the Lagos State coastline, in the West African sub-region of Nigeria. An estimated total of 2,273 fishermen using 702 boats were actively fishing along this coastline using different types of fishing gear including gillnets, purse seine nets and longlines. The population of fishermen in the communities ranged from 99 to 1,109 individuals. Gillnets had the highest recorded bycatch of Atlantic loggerhead turtles (*Caretta caretta*), a dominant species in the region. Collaborative efforts between research staff and the communities for the rescue and release of sea turtles have been consistent. A holistic approach for the conservation of sea turtles involving all stakeholders includes the collection of scientific data to generate a database, enforcement of existing regulations, an

increase in sensitisation and enlightenment, as well as introduction of alternative livelihoods for wealth creation in the coastal communities.

GREEN TURTLE CAPTURES IN NET FISHERIES IN THE PORT OF CONSTANTE, PERU

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We present data collected from an onboard observer program and monthly beach surveys. Data were collected from December 2007 to April 2009 in Constante (05°35' S, 81°00' W), an artisanal fishing port in Sechura Bay, northern Peru. Data we previously gathered from the area indicated a significant bycatch of sea turtles by fishing vessels, with green turtles (*Chelonia mydas*) being the most commonly captured species. Despite the existence of national legislation since 1995 banning the capture of sea turtles and commerce in their products, this coastal community commonly trades sea turtle products and consumes sea turtle meat for an important source of protein in their daily diet and for medicinal uses. A total of 43 green sea turtles were captured during 14 monitored trips (3 trawlers, 9 bottom set nets and 2 monofilament coastal nets). All monitored trips with sea turtle interactions were by bottom set net vessels (n=6). Of the 43 green sea turtles captured, 38 turtles were entangled and alive, 5 turtles were dead and 2 were observed. Of these, 35 turtles were released alive, 3 were discard dead and 4 were sold; the price was approximately $7.00 US per animal (S/20.00 soles). In addition, during beach surveys a total of 92 green turtle carapaces were collected and measured (CCLmin, CCLmax and CCW) to estimate the monthly sea turtle mortality rate. All carapaces found in Constante were from juvenile or sub-adult green turtles (CCL mean ±SD 60.2 ± 6.8 cm, range: 52.0–92.0 cm, n=92). These results indicate that Sechura Bay is a regionally important year-round juvenile green turtle foraging area and is still one of the principal areas for concern regarding high levels of sea turtle bycatch. Based upon this monitoring project and information on fishing effort, it is likely that annual captures of green turtles in Constante are in the order of many hundreds of animals. To decrease sea turtle captures and commerce, efforts are needed to offer fishermen new economic alternatives. Additional efforts should include an education and research program targeting the Constante community.

MAGNITUDE OF OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) TURTLES KILLED/POACHED FOR DERIVING ECONOMIC BENEFITS FROM VARIOUS PARTS OF THE SUB-CONTINENT 2001 TO 2002

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Wildlife helps us in maintaining the "Balance of Nature." Once this ecological equilibrium is disturbed, it will lead to many problems. The poaching of carnivores will help the herbivores to multiply in large numbers which in turn affects the forest vegetation. If the herbivores do not get enough food within the protected areas, they will invade nearby cultivated lands and ultimately bring misery to farmers. Further, the absence of forest cover will result in monsoon failures and eventually will affect the economy of our country. Orissa is the largest breeding and nesting ground of olive ridley sea turtles (*Lepidochelys olivacea*) in the world. According to an estimate, more than 75,000 dead olive ridleys have been counted on the Orissa coast over the past five years. Further it is believed that more than 20,000 of these turtles died during the year 2000 alone due to mechanized trawling in prohibited areas without the use of the Turtle Excluder Devices (TEDs). The endangered olive ridleys were illegally killed more in numbers (108,030)*. According to Das (2001), Orissa is the largest breeding and nesting ground for this species in the world. But this might not persist for a long time, if current mortality rates persist. The illegal large-scale mechanized fishing activities in the restricted no-fishing zones and the lack of enforcement were the reasons for the indiscriminate killing of very large numbers of olive ridley turtles along the Gahirmatha coast of Orissa. They are either cut open by the rotary blades of mechanized fishing trawlers or suffocated by the fishing nets: the cadavers pock mark the shores, raising a nauseating stench. More importantly, these deaths raise the hackles of

conservationists and push the already threatened turtles to the brink of near extinction. * Total number of animals poached/dead figure was derived from summing of all animals (source Tables 1 to 7 of present work).

*STUDY ON SEA TURTLE MORTALITY RISK FROM DRIFTING FISH AGGREGATION DEVICES

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A study on sea turtle mortality risk from drifting Fish Aggregating Devices (FADs) was conducted by the M.V. SEAFDEC (Southeast Asian Fisheries Development Center) during purse seine fishing operations in the Eastern Indian Ocean between December 2002 and January 2003. The main objective of the study was to investigate incidental catch of marine mammals and sea turtles caused by using drifting FADs in tuna purse seine fishing in the Indian Ocean. Experimental fishing using various types of drifting FADs was also conducted to examine their effect on sea turtle mortality. Two types of drifting FADs were used in the experiment, including 14 raft types and 3 curtain types. During the survey, 4 abandoned European drifting FADs were found and the incidental catch by these FADs were recorded. A total of 103 marine animals of 13 species were accidentally caught by 7 FADs of SEAFDEC and 3 abandoned European drifting FADs. A total of 30 marine turtles were accidentally caught by SEAFDEC FADs and 3 abandoned FADs mentioned above. From these, 28 were caught by the abandoned European FADs. The incidental catch of other species was composed of 7 porpoises, 10 sharks, 7 tripletails, 13 rainbow runners, 3 seachubs, 2 wahoos, 1 skipjack, 1 barracuda and 1 remora. The results of this study show that both types of drifting FADs caused sea turtle mortality. However, the curtain type of drifting FADs showed less risk for sea turtle mortality in comparison with the raft type. The greatest risk for sea turtle mortality was in abandoned drifting FADs. Approximately 90% of sea turtles incidentally caught in the Indian Ocean were found entangled in abandoned drifting FADs.

TOWARD ESTIMATING THE POTENTIAL BIOLOGICAL REMOVAL OF SEA TURTLE POPULATIONS

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Sea turtle populations pose numerous challenges to estimating how many individuals may be sustainably removed each year through incidental fisheries bycatch. Population parameters are difficult to estimate with precision, making population estimates, projections, and impact assessments unsatisfactorily error-prone once uncertainty is propagated through models. And even where good parameter estimates are obtainable, long time lags in population dynamics and untestable assumptions make the short-term effects of management actions nearly impossible to reliably predict. Therefore, it may be prudent to decouple the objectives of developing good biological models from developing useful management tools. We show how the Potential Biological Removal framework used for marine mammals (under the U.S. Marine Mammal Protection Act) may be adapted to set fisheries bycatch limits for sea turtle populations. The approach combines simple ecological theory, precautionary principles, and some data to construct tools that may be inadequate for describing real system dynamics but may nevertheless help meet management goals of recovering sea turtle populations.

*ASSESSING THE STATUS OF THE ARTISANAL MARINE TURTLE FISHERY IN MADAGASCAR USING LOCAL SOUS COLLECTEURS

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Hunting of turtles is widespread in Madagascar. On the west coast particularly, turtle hunting is considered an important traditional and cultural activity by the Vezo fishing communities. Over the last twenty years there has been a shift from traditional subsistence turtle hunting to a more commercially-focused fishery to supply the turtle meat market within Madagascar. Although turtle hunting is illegal under national law, there are currently no government initiatives to manage and control the artisanal turtle fishery. Furthermore, there has been no thorough assessment on the level of exploitation of turtles since 1989 and the lack of reliable, up-to-date data on the current status of turtle populations throughout Madagascar prevent the creation of viable conservation management plans. This study reports on the monitoring of the artisanal marine turtle fishery along 60 km of coastline in southwest Madagascar throughout 2007. Community members, or sous collecteurs, from 12 villages were trained and employed to collect biological and fisheries data on landed turtles. Data collectors were also provided with, and trained to use digital cameras to provide a visual record of each turtle catch recorded. A total of 699 marine turtle landings were recorded during the study, including four species of turtle (green, *Chelonia mydas*; hawksbill, *Eretmochelys imbricata*; loggerhead, *Caretta caretta*; olive ridley, *Lepidochelys olivacea*). Previous estimates of the nationwide marine turtle catch ranged from 11,000 to 15,000. Contextualising our data with other recent reports, we estimate that in excess of 13,000 turtles are caught annually in the southwest region alone. Thus the national fishery remains large. Locally-based monitoring can provide meaningful data and are likely to give a more accurate assessment of a fishery than through fishermen interviews alone. The reliability of the data was increased through verification from the digital camera records and the employment of a Malagasy field assistant from one of the villages in the study. This study also highlights a cost efficient method to collect information from data poor areas whilst increasing local capacity, creating awareness and gaining trust amongst the local communities, as turtle catches are reported without fear of prosecution. The relationship developed between the researchers and the turtle fishers has allowed for the first steps of turtle fishery management to be explored in this region, with full cooperation of the local community.

CURRENT STATUS OF ARTISANAL FISHERIES ALONG THE COAST OF PONDICHERRY AND TWO DISTRICTS OF TAMIL NADU: CUDDALORE AND VILLUPURAM

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Fisheries research in India has been sporadic and predominantly focused on single species groups rather than the entire spectrum of its characteristic multi-species multi-gear fishery. Considering that the fisheries sector is highly dynamic and constantly evolving in order to sustain itself with a greater emphasis on the mechanized sector, a need to research the artisanal sector was felt. With the prevailing perception being that diversity in fish catch is declining, as well as individual size and abundance, such work is required to be able to better inform management strategies supposedly employed in the region. This study attempts to represent the status of artisanal fisheries of the state of Pondicherry and the two districts, Cuddalore and Villupuram of Tamil Nadu, in terms of local species diversity, catch composition and abundance, and fishing capacities as well as implementation (or the lack of it) of specifications made by the Tamil Nadu Marine Fisheries Regulation Act (MFRA). The usual mode of collecting fisheries data tends to occur at ports and major landing centres. We, however, selected 17 fishing villages of varying size, to understand the capacities and the effort spread across the region thus also including a neglected but important contributor to the fishing industry. An extensive survey was conducted across these fishing villages for a period of six months which comprised landing surveys consisting of fishery related questions with regard to type of craft and gear, manpower involved and time spent fishing, all comprising the current fishing effort expended in the

region. Regular counts of craft used and unused were also done to assess the fishing capacity of the same. Alongside this, photographic samples of fish catches were collected and were analyzed for the purpose of identification, species measurements and counts. Identification up to species was attempted and entered into an exhaustive database, containing all species encountered. We have avoided using common names and clumping species under the 'miscellaneous' category. An exception was made only for the purpose of analyzing trophic data which was obtained from secondary literature. During the study, 83 families, 143 genera and 244 species were identified. These include species contributing to the bycatch and discard group. Gear employed in the region are mostly gill nets, trammel nets, shore and ring seines. Line fishing is also prevalent in the region. Catches comprised predominantly mid-level carnivores followed closely by the omnivores, herbivores and detrivores. A significant increase in fishing capacity was seen with tsunami relief featuring as the main contributor. A clear lack of implementation of specified rules as per the MFRA was also seen. The findings of our preliminary study conducted in the given region are presented here and serve as a baseline for fisheries of the same. Data collection will continue for the next two years in order to draw definite conclusions regarding the present status of fisheries which would then facilitate suitable management strategies catering to the fishery resource as well as the lives of the artisanal fisherfolk.

*REDUCING SEA TURTLES CAUGHT ON BOTTOM LONGLINES: INTEGRATING SEA TURTLE CONSERVATION INTO THE FISHERIES MANAGEMENT PROCESS

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The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) operates under mandates to minimize fishery bycatch to the extent practicable under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) and protect endangered and threatened species under the Endangered Species Act (ESA). In 2008, analysis of new observer program data indicated that boats fishing for groupers and other reef fish with bottom longlines in waters of the western Florida shelf have significantly more sea turtle bycatch than previously estimated. In response to this new information, the Gulf of Mexico Fishery Management Council and NMFS developed Amendment 31 to the Fishery Management Plan for Reef Fish Resources in the Gulf of Mexico to reduce sea turtle bycatch and mortality in the bottom longline component of the fishery. The purpose of Amendment 31 is to provide protection for threatened loggerhead sea turtles in compliance with the ESA and to reduce loggerhead sea turtle bycatch and bycatch mortality in compliance with National Standard 9 of the MSA. Actions considered in the amendment include: 1) modifying bait; 2) area, depth, and season restrictions; 3) reducing effort through a longline endorsement program; and 4) modifying fishing gear to reduce effort. The conservation measures proposed for implementation would: (1) reduce the number of bottom longline vessels operating in the fishery by about one half through bottom longline permit endorsement; (2) prohibit the use of reef fish bottom longline gear inside 35 fathoms east of Cape San Blas, Florida, from June through August; and (3) restrict the total number of hooks that may be possessed by each bottom longline vessel to 1,000; only 750 may be rigged for fishing. This suite of management measures proposed to be implemented is expected to substantially reduce loggerhead bycatch by reducing the number of vessels fishing with bottom longlines and amount bottom longline fishing effort.

*ANTHROPOGENIC IMPACT ASSESSMENT OF OLIVE RIDLEY TURTLES (*LEPIDOCHELYS OLIVACEA*) AND CHANGE DETECTION ANALYSIS OF THEIR NESTING BEACHES ALONG THE COAST OF WEST BENGAL, INDIA

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The nesting sites of olive ridleys (*Lepidochelys olivacea*) on the West Bengal Coast are decreasing day by day due to increasing incidental captures of sea turtles in marine trawl fisheries and rapid changes in the coastline. Along the 200 km shoreline of West Bengal is the world's largest mangrove forest. The Sundarban region is to the east and the Digha-Shankarpur open-beach region is to the west. The present study reveals that extensive trawling operations in the Digha-Shankarpur region cause large-scale mortalities of sea turtles in comparison to the Sundarban area, because more than 85% of fishermen are gill netters. Data on the incidental capture of sea turtles in marine trawl fisheries was collected by interviewing randomly selected fishermen between November 2008 and April 2009.

Change detection of sea turtle nesting beaches in West Bengal was conducted through analysis of multispectral images of the study area along with field surveys. The sandy beach has experienced a major change in various parts of the western and eastern flanks of Sundarban. The southern part of Sundarban has experienced a major land loss in the recent years. Erosion and accretion of sand on nesting beaches was prominent in Namkhana (Henry-Bakkhali-Fraserganj region), Dalhousie, Bulchery, Mousuni, Kalas, Mechua and other islands of Sundarban. Two nesting sites were reported during the study, one on Henry Island and another on Mousuni Island. Surprisingly, in the Digha-Shankarpur open-beach sector no nests were reported. This may be caused by increasing anthropogenic activity.

BANG FOR THE BUCK: THE ECONOMICS OF PERUVIAN ARTISANAL FISHERIES AND IMPLICATIONS FOR SEA TURTLE BYCATCH MITIGATION

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There is a need to understand the economics of fisheries in which bycatch occurs to garner insights into where the maximum impact may be achieved given limited resources for mitigation. As part of an ongoing bycatch research program, we collected data on economic aspects of four key artisanal fisheries along the Peruvian coast: longliners (for mahi mahi and sharks) and gillnets (bottom-set and driftnets). Data were obtained on the operational costs and income generated for a sample of fishing trips for each fishery. Longline vessels fishing for dorado averaged an investment in U.S. dollars of $1,958 per trip (range: $571 to $5,991, n=28 trips) while yielding an average net profit of $1,286 per trip (range: -$2,717 to $6,535, n=28 trips). Longline vessels targeting sharks, whose trips are typically longer in duration, required a greater average investment of $3,811.40 per trip (range: $500 to $12,698, n=21 trips). They also yielded a higher average net profit of $2,163 per trip (range $35.7 to $11,393, n=21 trips). In comparison with longliners, both investment and profits from bottom-set nets were lower. The average investment per bottom-set fishing trips was $22.90 ± 2.56 (range: $12.50 to $39.70, n=12 trips). For bottom-sets, the net profit per trip averaged $103.80 ± 93.80 (range: -$22.90 to $1,035.70, n=11). Approximately half of these trips (45.3%, n=5 trips) incurred a loss. Investment in driftnet trips averaged $592 ± 20.6 (range: $120 to $700, n=46 trips) and the average net profit per trip was $489 ± 183 (range: -$682 to $5,044, n=46 trips). A large number of trips with this gear also incurred a net loss (47.8%, n=22 trips). When combined with information on their sea turtle bycatch rates, a better understanding of the economics of these fisheries can help better inform future conservation and mitigation efforts. Clearly though, any efforts to promote changes in these fisheries (i.e. changes in fishing practices or introduction of mitigation measures) must take into account their razor thin profit margins, particularly those of net fisheries.

*IMPACT OF CURRENT FISHING PRACTICES ON ENDANGERED SPECIES IN THE GULF OF MANNAR BIOSPHERE RESERVE AREA: A CASE STUDY

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The Gulf of Mannar Biosphere Reserve (GOMBR) is rich in biodiversity, hosting a variety of marine species (3,600 species of flora and fauna). The reserve extends approximately 335 km from Dhanushkodi to Kanniyakumari in the Tamilnadu State of India. In this region, fishing occurs in all ecological niches by the artisanal and mechanized sectors, mainly targeting marine resources like shrimp, fish, cephalopods and blue crabs. The fishing gear includes shore seines, gill nets (pelagic and demersal), traps, bottom trawls (shrimp and fish), hook and line, spear fishing, scoop nets and Chank fishing. Illegal fishing gear, like paired trawls, purse seines and drag nets, are also used; as a result, conflicts are quite common in this region. Endangered species such as sea cucumbers are collected by bottom trawlers and skin divers and sold to agents. The peak season of catch is during the post monsoon period. Syngnathid fishes are collected with shore seine nets, bottom trawls, and drag nets and by skin diving during periods of high demand, which is during the monsoon period. Fishing communities in this region believe that seahorses have a medicinal value for curing asthma, especially in small children. Bottom trawl nets operated in the GOMBR region

do not use Turtle Excluder Devices. The sea turtles caught during fishing activities are usually thrown back, but in some cases they are utilized for human consumption. The sea turtles caught from shore seines and gills nets are not frequently thrown back into the sea. Some communities consider turtle meat a delicacy and believe in its medicinal value, especially green turtles (*Chelonia mydas*) in the Tuticorin Region and olive ridleys (*Lepidochelys olivacea*) in the Kanyakumari Region. During fishing activities, non-target species are caught incidentally or unintentionally, severely impacting the marine ecosystem, its biodiversity and the yield from the natural system. Even though a lot of enforcement has been extended to protect these endangered species, the clandestine trade in this region is still ongoing, mainly because of the pressure made by stakeholders.

FIRST EXPERIENCES USING TURTLE EXCLUDER DEVICES (TEDS) IN BOTTOM TRAWLERS IN THE WESTERN MEDITERRANEAN SEA

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Spain has one of the largest trawling fleets in the world, with over 1,000 vessels operating in the Gulf of Cadiz, Mediterranean Sea and international waters. The evaluation of the incidental catch of loggerhead turtles (*Caretta caretta*) in bottom trawlers carried out by the Chelonia Association in 2007 and 2008 concluded that about 5,000 turtles are captured annually in the Gulf of Cadiz and Spanish Mediterranean alone. A reduction in sea turtle bycatch by bottom trawling is urgently needed all over the world, using tools that allow for an international conservation program as well as sustainable fishing of commercial species by local peoples. The experiences of the French Institute of the Sea (IFREMER) in French Guiana since 1993 have shown that the use of Turtle Excluder Devices (TEDs) is extremely useful not only to avoid bycatch of turtles but also of other marine vertebrates (principally sharks and mammals). In June 2009, the Chelonia Association installed a Turtle Excluder Device in a bottom trawl vessel based in the port of Almeria (Andalusia, southeastern Spain, 36º50'00"N, 2°26'59"W). The structure was made of stainless steel, measuring 130 cm high and 108 cm wide, and had a bar diameter of 5 cm on the outer perimeter and a separation between bars of 9 cm. The escape opening for the net was directly above the TED to allow the turtles to escape. The TED installation did not involve any changes to the nets used. A total of five nets were set with the TED installed, three with the TED escape opened and two with the opening sealed. In each case, we confirmed that the volume of targeted species caught, mainly crustaceans (*Aristeus antennatus*, *Parapenaeus longirostris* and *Nephrops norvegicus*), did not vary according to the opening or closure of the output device. Also, we confirmed that total catch volumes did not vary with installation of the TED. However, the TED was responsible for a smaller catch volume of fish larger than 9 cm (which was the size of the space between the vertical bars) from non-target but marketable species, such as monkfish (*Lophius piscatorius*), mullet (*Mullus barbatus*), hake (*Merluccius merluccius*), horse mackerel (*Trachurus* sp.) and sole (*Solea vulgaris*). High bycatch was seen for small spotted catshark (*Scyliorhinus canicula*), eel (*Gymnammodytes cicerelus*) and herring (*Clupea harengus*). No sea turtles were caught, despite the large population of *C. caretta* in the area. These first experimental tests demonstrated the successful use of TEDs for the conditions studied, although the number of sets with different types of bottom trawl nets should be increased to test their effectiveness. Work is in progress elsewhere in the Spanish Mediterranean.

CIRCLE HOOK EFFECTIVENESS FOR THE MITIGATION OF SEA TURTLE BYCATCH AND CAPTURE OF TARGET SPECIES IN A BRAZILIAN PELAGIC LONGLINE FISHERY

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Incidental catch by the pelagic longline fishery is a major global threat for loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles. The reduction of incidental capture and post-release mortality of sea turtles in the Brazilian pelagic longline fishery, operating in the southwestern Atlantic Ocean, was investigated by comparing the performance of 18/0 circle hooks with 9/0 J-type (control) hooks. Hook selectivity experiments were performed between 2004 and 2008, in a total of 26 trips, 229 sets and 145,828 hooks. The experimental design included alternating control and experimental hooks along sections of the mainline. We demonstrated an overall decrease in loggerhead turtle capture rates by 55% and leatherbacks by 65% when using circle hooks. In addition, deep-hooking in loggerheads decreased significantly from 25% using J-hooks to 5.8% with circle hooks, potentially increasing post-release survival. Regarding captures of the main target species, circle hooks increased catch rates of most species, including tunas (bigeye, *Thunnus obesus* and albacore, *T. alalunga*), and sharks (blue, *Prionace glauca* and requiem sharks of the genus *Carcharinus*). We recorded a slight, non-significant increase in the capture of yellowfin tuna (*T. albacares*), shortfin mako sharks (*Isurus oxyrinchus*) and hammerhead sharks (*Sphyrna lewini* and *S. zygaena*) and a non-significant decrease in the capture of dolphinfish or mahi mahi (*Coryphaena hippurus*). On the other hand, a significant decrease in the capture rate of swordfish (*Xiphias gladius*) was detected when using circle hooks. Overall, results support the effectiveness of using circle hooks for the conservation of loggerhead and leatherback sea turtles, with positive effects on capture of most target species of the southwestern Atlantic longline fishery.

*ASSESSING THE CLINICAL EVOLUTION OF THE LESIONS CAUSED BY CIRCLE HOOKS IN THE DIGESTIVE TRACT OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*)

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Circle hooks have been proposed as a means of reducing the bycatch mortality of sea turtles in pelagic long-line fisheries to sustainable levels. Even though the use of circle hooks is encouraging, to date, no clinical long term studies on mortality of sea turtles captured on pelagic long-lines and released with the hook on have been developed. The aim of this study was to assess the short and long time mortality of sea turtles after the interaction with circle hooks, to monitor the evolution of the lesions produced by the hook and to monitor the clinical condition of the animals. Furthermore, the results were compared with those obtained in previous studies on J hook mortality, developed under the same conditions in 2002 and 2003 at CRAM Rehabilitation Centre. The clinical evolution of the lesions caused by circle hooks in the digestive tract of 11 loggerhead sea turtles (*Caretta caretta*) captured in Balearic Islands waters by a long-line fishery was studied for one year. The animals did not undergo any surgical procedure or veterinary treatment, but several clinical criteria of exclusion were established in order to prevent any risk for the animal. Throughout the study, different evolutions of the lesions were observed, mainly depending on the location and the anchorage of the hook. For hooks anchored in the mouth, great difficulty in their elimination was observed in the short term due to their morphology and the way they anchor at this location. Nevertheless, in the

long term, 70% of the cases hooks ended up getting loose and being released without any external intervention. The life of the animals was not compromised at any time during the study.

*SEA TURTLE BYCATCH IN TRAWL SURVEYS IN THE GULF OF GUINEA

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A 22-day resource survey was carried out in the Nigerian inshore coastal waters on the Gulf of Guinea, on board a 25 m out-rigger or boom trawler, FT Susainah. The trawl nets with cod end mesh of 20 mm were devoid of turtle excluder devices (TEDs) in order to carry out an unbiased assessment of the occurrence, abundance and distribution of fish, shellfish resources, sea turtles and other living organisms. The project also aimed to determine the current health status of the environment. Each of the daytime research trawling operations lasted for 30 minutes and covered 73 sampling stations along transect lines with 7 locations based on depth ranges of 10, 20, 30, 40, 50, 70 and 100 m. The hauls recorded low catch per unit effort (CPUE) of fish, shrimp, crabs and cephalopods. In all the hauls, two sea turtles (one loggerhead and one olive ridley sea turtle) were observed and were released immediately after necessary data had been recorded. Astronomically high volumes of solid waste were recorded against the mega-fauna catch at a ratio which ranged from 4:1 to 8:1. There were indications that the loss of biodiversity was being accentuated or exacerbated by continuous habitat degradation caused by uncontrolled commercial fish/shrimp trawling and the pollution of the environment from accidental oil discharge, as well as indiscriminate dumping of solid wastes including non-biodegradable nylon and plastic products and household items which occurred at depths up to 100 m. Apart from the existing regulations including the installation of Turtle Excluder Devices (TEDs) in shrimp trawl nets, recommendations are proffered for the maintenance of a healthy environment and conservation of sea turtles and other living resources as an integral part of biodiversity maintenance in order to bring about sustainable livelihoods of the fishermen.

*AN ASSESSMENT OF THE HARVEST OF MARINE TURTLES IN THE TURKS AND CAICOS ISLANDS, CARIBBEAN

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The Turks and Caicos Islands (TCI), a UK Overseas Territory in the Caribbean, permits the harvest of marine turtles for domestic consumption. Current TCI fisheries legislation protects turtle eggs and nesting females on the beaches, but allows the capture of any turtle species at sea with a minimum size of 20 in (51 cm) curved carapace length and 20 lbs (9 kg) or more in weight. Here we summarise the results of one year of biological sampling of green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles landed for consumption in South Caicos, the main fishing centre of the TCI. Collaboration with fishermen has facilitated gross examination of the gonads of butchered individuals allowing an assessment of sex of harvested animals and yield of edible mass across size classes. Comparison of the size-class distributions of harvested green and hawksbill turtles with those captured during our in-water surveys indicates that fishermen are targeting larger individuals. Most turtles captured for consumption were opportunistically taken whilst fishing for scalefish, conch or lobster, rather than directly targeted. Nevertheless, using direct counts of butchered turtles we suggest that the TCI harvest remains one of the largest legal marine turtle fisheries in the region.

TURTLE BYCATCH IN COASTAL FISHERIES – CHENNAI COAST

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Tamil Nadu with its 980 km coastline has both east (900 km) and west (80 km) coasts. A considerable number of sporadic nesting beaches for olive ridley turtles are available along Tamil Nadu coast and in particular in the Chennai area on the southern Chennai coast. A survey was conducted from December 2009 to May 2010 in order to determine the number of dead olive ridleys along the beach in Chennai. Surveys were conducted along a 13 km stretch in the Chennai coastal area, from Periya Neelankarai to Reddy Kuppam. In these areas, a considerable number of olive ridleys nest and a large number of fishing activities occur daily. Many marine turtles become victims of modern fishing gear: well over 5,000 turtles are entangled annually in floating and bottom set gill nets, and shrimp trawling and baited hooks also cause serious damage. However, artisanal fishing gear also poses a threat to nesting turtles. To assess this threat, this study used a questionnaire to assess turtle bycatch in artisanal fishing gear and documented morphology and visible injuries of dead, stranded sea turtles.

MULTIYEAR ANALYSIS OF SEA TURTLE BYCATCH BY PERUVIAN LONGLINE FISHERIES: A GENETIC PERSPECTIVE

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The capture of non-target species (i.e. bycatch) by longline fisheries is a major cause of the decline of many marine species around the world, including sea turtles. However, we have a limited knowledge of the impact over focal populations or sub-populations and current knowledge is usually based on single sampling events. Since 2003, we have been monitoring the interaction between Peruvian longline fisheries and the aggregations of sea turtles in the open ocean. In addition to general information collected from each sea turtle taken as bycatch (i.e. species, weight, size, approximate life-stage, and gender), we collected tissue samples to investigate the genetic diversity and structure of the turtles aggregated in the oceanic waters off Peru, and to estimate the most likely rookery of origin. Here, we present a multi-year analysis of samples collected during on-board observations conducted from 2003 to 2009. We sequenced a 740bp fragment of the mtDNA control region and inferred the haplotype (HP) of 150 sea turtles, corresponding to three species: *Caretta caretta* (n=41, HP=3), *Chelonia mydas* (n=82, HP=11), and *Lepidochelys olivacea* (n=27, HP=6). Total diversity of haplotypes included four new reports for the green turtle and one new report for both the olive ridley and the loggerhead turtle. We did not observe changes in haplotype dominance among years; however, rare haplotypes (i.e., low frequency) varied from year to year. Results suggest that Peruvian longline fisheries operating in the South East Pacific interact with loggerhead turtles migrating from East Australia and New Caledonia rookeries, green turtles from Mexico and Costa Rica and possibly from the Galapagos Islands, and olive ridley turtles from Mexican and Colombian rookeries. However, the finding of new haplotypes in a relatively small sample size stresses the need to continue genetic research in the Eastern Pacific sea turtle rookeries. Our study highlights the importance of Peruvian waters for sea turtles throughout the Pacific basin and reveals the wide geographic impact that local fisheries can have on several populations of highly migratory marine species.

*GLOBAL PATTERNS OF MARINE TURTLE BYCATCH: IDENTIFICATION OF CONSERVATION AND RESEARCH PRIORITIES

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Fisheries bycatch has been identified as a primary driver of population declines in several species of marine megafauna (e.g., elasmobranchs, marine mammals, seabirds, marine turtles). Characterizing the global bycatch seascape using data on bycatch rates across fisheries is essential for highlighting conservation priorities. We compiled a comprehensive database of reported data on marine turtle bycatch in gillnet, longline, and trawl fisheries worldwide from 1990–2008 (~200 studies), including bycatch rates, observed effort, and demographic classes of turtles taken as bycatch. The total reported global marine turtle bycatch was ~85,000 turtles, which likely underestimates the actual total by two orders of magnitude due to severe under-representation of overall global bycatch in publicly available reports and the small percentage of fishing effort observed. Our synthesis also highlighted an apparently universal pattern across fishing gears and regions where extremely high bycatch rates were associated with low amounts of observed effort, which emphasizes the need for strategic bycatch data collection and reporting. This study provides the first global perspective of fisheries bycatch for marine turtles and highlights region-fishing gear combinations of most concern that warrant urgent conservation action (e.g., gillnets, longlines, and trawls in the Mediterranean and Eastern Pacific) and region-gear combinations in need of enhanced observation and reporting efforts (e.g. East Indian Ocean gillnets, West African trawls).

*MARINE TURTLE STRANDINGS IN TANZANIA: THE NEED FOR A REVIEW OF FISHERIES LEGISLATION

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The Tanzanian coast stretches for 900 km and boasts an array of rich and diverse habitats that support five of the seven species of marine turtle. Leatherback, loggerhead and olive ridley turtles are known to forage in Tanzanian waters and migrate through en route to nesting sites elsewhere in the region. Green and hawksbill turtles breed and nest in Tanzania. Conservation efforts have largely focused on protecting nesting females and their eggs. However, on average, 200 dead turtles are washed up on Tanzania's beaches each year with many showing evidence of net entanglement. In 2004, in response to the high number of turtle strandings, Sea Sense established a community based turtle stranding network which now operates in eight coastal districts. Over 60 community members have been recruited and trained in turtle species identification, collection of biometric data from stranded individuals and classification of causes of death. The objectives of the stranding network are to identify temporal and spatial trends in mortalities, quantify specific threats to turtles in Tanzania and assist with the development of recommendations to mitigate risks. Data were analysed for the period July 2004–July 2009. Over 75% of recorded mortalities were green turtles. The mean, minimum and maximum curved carapace length (CCL) was 67.6 cm, 18 cm and 148 cm respectively. More than 60% had a CCL measuring less than 80 cm, which is less than the average green turtle CCL at sexual maturity (80–110 cm). This suggests that Tanzanian waters pose a significant threat to juvenile green turtles. In a third of all recorded stranding cases, turtles showed evidence of injury including knife wounds on the head, neck and flippers. Total flipper amputation was common. Most of the injuries were a result of disentanglement from fishing nets but it is not known whether these injuries occurred before or after death. Carapaces and discarded intestines were also frequently reported, indicating that turtle slaughter is commonplace in Tanzania. Temeke District, south of Dar es Salaam, has the highest recorded rate of turtle mortalities in Tanzania. The area is a key breeding and nesting site for green turtles and hence there are a high number of turtles in inshore waters exposed to subsistence hunters, harmful fishing gears and pollution. Temeke District is also one of the three commercial prawn trawl zones in Tanzania. Prawn trawling is known to pose a significant threat to turtles and critical foraging habitat. It is clear that foraging and migrating turtle populations are facing increasing risks from fisheries interactions in

Tanzanian waters. Gillnets, dynamite fishing and commercial prawn trawling pose the biggest threats. The turtle stranding network is providing valuable data on the distribution and likely causes of turtle mortality in Tanzania but without a targeted action plan to mitigate these threats together with a change in fisheries legislation incorporating the mandatory use of Turtle Excluder Devices (TEDs), turtle populations in Tanzania will continue to be under threat.

FORAGING

HELMINTH FAUNA COULD REFLECT THE ONTOGENETIC HABITAT SHIFT OF MEDITERRANEAN LOGGERHEAD TURTLES, *CARETTA CARETTA*

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We examined the gastrointestinal helminth fauna of 182 juvenile loggerhead sea turtles, *Caretta caretta*, collected in 6 localities from the Central and Western Mediterranean. Turtles were obtained from different sources. Turtles from the Central Mediterranean were obtained from rescue centers and had either been found freshly dead, or were wounded or diseased and died in the recovery centre. Turtles from the Western Mediterranean were obtained from two sources, a sample of 44 freshly dead turtles found stranded, and a sample of 54 turtles by-caught by trawlers. Distribution of CCL and dietary data suggested that sampling covered a broad spectrum of habitat use by the turtles, from the oceanic stage to the neritic stage. Fifteen helminth taxa (10 digeneans, 4 nematodes and 1 acanthocephalan) were identified, of which 12 were specialist to marine turtles; very low numbers of immature individuals of 3 species typical from fish or cetaceans were also found. There were strong dissimilarities in the helminth fauna between turtles from different localities. Small turtles from Calabria harbored only the 2 digenean species that were regionally the most frequent, i.e. *Enodiotrema megachondrus* and *Calycodes anthos*, and the mean abundance of worms per turtle was just 7.5. The diversity (range: 4–8 species) and mean abundance (range: 43.1–131.4) of helminths increased in turtles with intermediate sizes collected in Sicily, Valencia and the NW Mediterranean. Finally, the largest turtles, collected from Campania, harbored as many as 11 helminth taxa; mean abundance of worms, however, did not increase (57.4). Although an influence of local factors on the diversity and composition of helminth fauna cannot be rule out, the overall pattern is compatible with the hypothesis that parasite communities reflect the ontogenetic shift that juvenile loggerheads undergo from oceanic to neritic habitats.

*DAILY AND SEASONAL FEEDING RHYTHM OF GREEN TURTLES IN A MULTISPECIFIC SEAGRASS MEADOW AT MAYOTTE

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Little is known about the foraging behaviour of sea turtles, which undergo long distance migrations. Studies where the actual diving behaviour is related to their feeding activity are still rare, meaning that most of our understanding of sea turtle biology remains parcelled, leading to biased estimations of their ecology and contribution to ecosystem functioning. The green turtle is the only sea turtle mostly feeding on shallow coastal seagrass and algae meadows and is, as such, relatively more accessible than other sea turtle species. Accordingly, we investigated the daily and seasonal feeding rhythm of green turtles foraging on a coastal multispecific seagrass meadow at Mayotte Island (12°58'S, 45°05'E), in the South Western Indian Ocean. From 2005 to 2008 a total of nineteen mature green turtles were instrumented with an electronic time-temperature-depth recorders from 3 to 24 days and concurrently directly observed during underwater surveys. Additionally, three of these turtles were concurrently instrumented with a fast-acquisition global positioning system (FGPS). Green turtles displayed a high fidelity to the study site and mostly

remained on the seabed close to the shore. They mostly performed short (12.6 ± 3.1 min) and shallow (3.3 ± 0.1 m) U-shaped dives consistent with the local shallow bathymetry, yet under direct influence of tidal regime. At the scale of the day, analysis of dive patterns and a fine-scale behavioural tracking, using the FGPS and direct underwater observations, suggested two main dive categories: short-shallow foraging dives (6 min for 2 m) occurring during daytime on the seagrass meadow whereas long-deep resting dives (51 min for 10 m) occurred at night on coral and rocky areas. The light-related foraging pattern of green turtles was likely to increase turtles' feeding efficiency. At the scale of the seasons, dive durations ranged from 15.7 to 9.5 min between winter and summer, and were negatively correlated to mean water temperatures, ranging from 25.7 to 29.3 °C, respectively. Consistently with the documented seasonal metabolic depression in winter, the diving activity decreased with decreasing temperature. The feeding duration was estimated to be 10.9 ± 0.3 h/day and presented no significant seasonal variation, despite a lower metabolic rate in winter. While no seasonal change was previously documented in seagrass production, this suggests that green turtles maintain a constant food intake year-round. Our study shows the importance of shallow coastal habitat for green turtles and contributes to better assess the ecology and conservation issues of this endangered species.

INFLUENCE OF OCEANOGRAPHIC VARIABLES, MARINE CURRENTS AND ARTISANAL FISHERIES ON SEA TURTLE POPULATIONS IN THE GULF OF VENEZUELA

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Fluctuations analysis on threatened species must be conducted in a systematic manner, including as many factors as possible (biotic and abiotic) that might influence the intrinsic processes of the population studied. Because of this, research teams in sea turtle feeding grounds worldwide have included in their working routines remote sensors and environmental data capture to elucidate population increases and decreases. Several authors have analyzed oceanographic characteristics (salinity, tides, sea surface temperature, winds) and marine currents that affect food availability, population densities increases, seasonal movements, and habitat use, among others; also, artisanal fisheries and pollution can be a negative influence the survival of sea turtles. The propose of this study is to analyze the Gulf of Venezuela (GV) as an ecosystem suitable for use by sea turtles and verify in the field the variations in densities of sea turtle populations at different localities throughout the study area. Analysis of environmental fluctuations of abiotic factors such as winds, salinity, tides, moon phases and currents, and the predominant types of grounds in areas (seagrass, reef patches, sandy bottoms) were carried out; parallel to this investigations, other studies about artisanal fisheries developed along the coast by Wayuu indigenous people and the incidence of pollution (oil and plastic) were carried out. The study area was divided into three zones according to the dominant ground type: A: north (from Castilletes–Cuzia); B: middle (Cojoro–Paraguaipoa) and C: south (Caimare Chico–Cienaga Los Olivitos). We analyzed for each zone oscillations in densities/species per year, and then compared it with the environmental changes of the area. It was found that changes in the patterns and intensity of the winds promote an increase in the presence of green turtle individuals in areas other than seagrass beds; we also analyzed qualitatively the fluctuations of the two main ocean currents (both coastal) over time, establishing that the abundance of juveniles (*C. mydas*, *C. caretta*, *E. imbricata* and *D. coriacea*) varied greatly throughout the study area compared to previous years. The estuary plume of Maracaibo "Lake" has influenced the entrance and exit of freshwater to the GV and therefore salinity ranges between 8 and 36 ups, favoring the presence of sea turtles at average salinity levels possibly as a result from the displacement of prey (fish, squid and crabs). The human factors such as artisanal fisheries and human settlements (urban and rural) in the Maracaibo Lake system negatively impact sea turtle populations due to growing sea turtle-fisheries interactions and high levels of pollution (mostly plastic), respectively. Coupled to this, sea turtles were found with traces of oil as a result of oil bodies drifted far along by ocean currents and winds to areas where they feed. It is necessary to continuously and systematically record environmental data to develop a protection plan for the sea turtles that inhabit the waters of this important feeding area of the southern Caribbean.

GENETIC ANALYSIS OF JUVENILE HAWKSBILLS FROM A FEEDING GROUND IN THE DOMINICAN REPUBLIC

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In the Caribbean, genetic studies have shown that foraging aggregations of hawksbills (*Eretmochelys imbricata*) comprise turtles of multiple stock origins from far ranging areas. There is a need to expand genetic studies to include many other foraging sites, larger sample sizes, and additional sequence data before a complete understanding of the composition of these aggregations can be obtained. Studies of foraging areas through time are also important to determine how declines or increases in nesting population sizes from contributing rookeries affect the foraging aggregations. Genetic studies of hawksbill turtles have extensively used mtDNA as a marker to trace matriarchal lineages that can be associated to specific rookeries from the region, and thus, likely origins of juveniles found in foraging aggregations. Originally, a 380bp sequence from the d-loop was used. In later years a longer sequence of 480bp, and finally 740bp was established, allowing the identification of multiple haplotypes previously considered as one. We therefore analyzed the d-loop 740bp mtDNA fragment from a hawksbill sea turtle feeding aggregation in Jaragua National Park (JNP, Southwest of Dominican Republic). Since 1996, a saturation tagging program has been conducted in the study area during yearly field trips. Out of 196 samples collected between 1997 and 2009, to date we have analyzed a total of 87 samples (n=23, 1998; n=9, 2008; n=55, 2009) from hawksbill turtles in their foraging habitat. We determined mtDNA haplotype frequencies from published data on eight nesting rookeries to establish their contribution to our foraging habitat. In agreement with previous studies of foraging aggregations, we found 15 haplotypes belonging to different rookeries. The three most likely major rookeries that contribute to our foraging ground in DR were haplotype Ei-A01 (CU1 or A) from Cuba, haplotype Ei-A11 (PR1 or F) from Puerto Rico and in lesser frequency we found contributions from Mexico (haplotype Q). These results could be explained by the geographical proximity of Cuba and Puerto Rico to the Dominican Republic, as well as the large nesting populations of Puerto Rico and Mexico. In addition, we identified three new haplotype sequences, of which one was related to the Q haplotype (Mexico) and was classified as Ei-A83, one was not related to any other sequence and was classified as Ei-A84, and one closely resembled the Ei-A60 haplotype (Puerto Rico).

*GROWTH RATES AND AGE AT MATURITY OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN THE MEDITERRANEAN SEA, ESTIMATED THROUGH SKELETOCHRONOLOGY

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Growth rates of juvenile loggerhead sea turtles (*Caretta caretta*) in the Mediterranean Sea were estimated through a skeletochronological approach. Fifty-five dead turtles ranging 24–86.5 cm Curved Carapace Length (CCL) were collected from the central Mediterranean. Humeri sections were obtained and treated to show growth marks, assuming the production of one layer each year. Two methods were used to estimate a somatic growth function in the form of a Von Bertalanffy Growth Function. The first method used a correction factor to estimate the reabsorbed layers and so the age of each individual turtle at death. The second method used a back calculation approach to estimate the size corresponding to old layers, in order to provide the growth of each turtle in a time interval. Individual mean growth rates ranged from 1.3–6.0 cm/yr and a great inter- and intra-individual variability of growth rates was observed, suggesting a great environmental variability experienced by these turtles during their lives. The results of the two methods were similar and indicated that turtles would take 14–27 years to reach 66.5–84.7 cm CCL, the average nesting female sizes observed in the most important Mediterranean nesting sites, which can be considered as an approximation of size at maturity. This estimation is very close to a previous one obtained through

a different method, confirming the estimation of age at maturity for Mediterranean loggerhead turtles and supporting the validity of all these methods.

*STOCK ORIGIN OF LEATHERBACKS (*DERMOCHELYS CORIACEA*) FORAGING IN THE SOUTHEASTERN PACIFIC

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Eastern Pacific leatherback nesting populations are severely depleted and have become an international conservation priority. Previous satellite telemetry studies and tag return data have shown that post-nesting females migrate from beaches in Costa Rica and Mexico to foraging areas off the coast of South America. Therefore it appears that some leatherbacks found in the southeastern Pacific are part of the eastern Pacific breeding stock. However, these studies do not take into account males, non-nesting females and juveniles that are also utilizing these foraging areas. We used molecular genetic approaches to determine the nesting stock origin of leatherbacks foraging off the coast of Peru and Chile in the southeastern Pacific. A total of 59 tissue samples were analyzed from juvenile and adult leatherbacks caught in longline and gillnet fisheries, as well as from stranded turtles from the coasts of Peru and Chile. 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. Results show that approximately 15% of the leatherbacks analyzed originated from the western Pacific breeding stock. This indicates that not all leatherbacks foraging in the southeastern Pacific are from the eastern Pacific breeding stock. This study illustrates the importance of integrating genetic data with those from satellite telemetry to obtain an accurate understanding of habitat use and population structure for risk analysis. These results have important fisheries management and conservation implications for leatherback populations across the Pacific.

LONG-TERM TRENDS IN LOGGERHEAD TURTLE CAPTURES AT THE ST. LUCIE POWER PLANT, HUTCHINSON ISLAND, FLORIDA USA

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The St. Lucie Nuclear Power Plant, operated by Florida Power and Light Company and located on the east central coast of Florida USA, has a long term database of turtle captures dating back to 1976. The power plant serves as a uniquely unbiased sampling device, as large amounts of cooling water are drawn into the plant from the ocean 24 hours a day, 365 days a year. A considerable number of sea turtles are entrained with this cooling water, and the plant has a sea turtle conservation program in place to safely capture, tag, and release sea turtles from the power plant intake canal. A total of 7,523 loggerhead turtles, with a range of Straight-Line Carapace Lengths (SCL) from 39.8 cm to 108.0 cm, have been captured at the plant since 1976. There has been a marked decline in loggerhead sea turtle nesting in Florida since 2000, as reflected in the Florida Index Nesting Beach Survey (INBS) data. We examined both INBS nesting data and St. Lucie Plant canal capture data for adult loggerheads (SCL >87 cm) for the period from 1989–2008 to determine if there was a relationship between INBS loggerhead nesting numbers and captures of adult loggerheads at the St. Lucie Plant. We also examined the capture records of large subadult loggerheads (SCL 70–87 cm) at the St. Lucie Plant from 1989 to 2008. Capture rates for this size class range have increased dramatically from 2000–2008 as compared to the period from 1989–1999. To the extent that these canal captures represent the cohort of individuals reaching reproductive size in the next few years, it may represent a positive indication for future loggerhead nesting trends in Florida.

*HOW MUCH DO CORAL REEFS REALLY MATTER TO HAWKSBILL TURTLES MIGRATING FROM THE DOMINICAN REPUBLIC?

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We satellite tracked ten post nesting female hawksbill turtles from the Dominican Republic (DR) to investigate the extent to which they used coral reefs and how climate change may impact their foraging distribution. Location data, received from the tags via STAT, were filtered and integrated with bathymetry and reef location data (Reefs at Risk in the Caribbean database). While seven turtles headed away from the DR (to foraging grounds in Honduras, Nicaragua, Turks and Caicos and the Bahamas), three turtles did not leave the eastern Greater Antilles, with two remaining in the DR, and one heading only as far as Puerto Rico. Although turtles migrated over deep waters (maximum depth 5,146 m), and appeared to be affected by surface currents during migration, they preferred shallow coastal foraging areas in the vicinity of major reef areas. We digitised other published Caribbean hawksbill tracks (total n=31 turtles, adult males, females and juveniles) to describe their habitat preferences and therefore construct a Caribbean-wide picture of suitable foraging habitat for hawksbill turtles, including foraging range size. We assessed the level of protection afforded to Caribbean hawksbills by assessing the MPA status of reefs that hawksbills foraged on and highlight the importance of international cooperation for effective conservation. Finally, we investigated how future available habitat may change for Caribbean hawksbill turtles by overlaying modelled future climate data and Caribbean reef locations.

THE GROWTH OF NORTH PACIFIC LOGGERHEAD TURTLES ESTIMATED FROM MARK-AND-RECAPTURE RECORDS AND SKELETOCHRONOLOGICAL ANALYSIS

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Northern Pacific loggerhead turtles appear around the coastal waters of Japan before sexual maturity. Our previous study revealed an average SCL of 751 ± 68 mm (range: 563–1050 mm). Their growth rates were estimated by mark-and-recapture records and skeletochronological analysis in this study. One thousand and four loggerhead turtles were incidentally captured by pound nets in Muroto, Japan, from July 2002 to September 2009 and were released with flipper tags after SCL was measured. Sixteen of these turtles were recaptured and remeasured at least 50 days post release. Growth rate in each individual was calculated using SCL at release and recapture. SCL was 790 ± 55 (SD) mm at the time of release. Growth rate was calculated as 13.6 ± 14.8 mm/year (range: 0.0–52.4 mm). SCL of the fastest growth was 52.4 mm/year – growing from 720 mm at release to 918 mm at recapture within a 1380 days period. Growth rates varied among individuals, especially in the smaller SCL class; 650–699 mm: 11.6 mm/year (n = 1), 700–749 mm: 28.7 ± 25.3 mm/year (n = 3), 750–799 mm: 19.0 ± 13.5 mm/year (n = 3), 800–849 mm: 7.6 ± 8.0 mm/year (n = 8), 850–899 mm: 2.4 mm/year (n = 1). For comparison, skeletochronology was undertaken on humeri of 79 dead (bycatch or stranded) loggerhead turtles. SCL was 758 ± 61 mm and ranged from 577 mm to 944 mm. Growth marks in the humeri were measured and growth rates were estimated by correction factor protocol and regression growth protocol. Mean growth rate from correction factor protocol was estimated at 13.9 ± 7.8 mm/year. Growth rates at SCL 600, 700, 800, and 900 mm were estimated from regression growth protocol as 17.0, 14.0, 10.9, and 7.8 mm/year, respectively. The estimated values of growth rate from skeletochronological analysis coincided with the found value from mark-and-recapture records. Then, we compared the growth rate of this study

with that of other studies because growth rate differs among populations and habitats. Previous mark-and-recapture studies mentioned growth rates of northern Atlantic and Mediterranean populations of the same size as in this study. The northern Atlantic population was calculated as 17.2 (95% CI: 15.4–19.2) mm/year in SCL 500–800 mm and the Mediterranean population was calculated as 25 ± 17 mm/year in curved carapace length 325–820 mm. The growth rate of the north Pacific population seems somewhat less than that of north Atlantic and Mediterranean populations.

SCUBA DIVERS CONTRIBUTION TO MARINE TURTLE MONITORING USING PHOTO-ID METHOD

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Recognition and tracking of individual marine turtles are mostly achieved through invasive methods based on checking artificial tags (metallic or PIT tags). These methods, that require capture and handling of the animal, may induce stress or damage, and are difficult to apply with large individuals foraging outside the reef barrier. Photo-ID, relying on natural marks on the body, can be used to complement these methods (e.g. if a tag is lost), or may eventually replace them. We investigated and validated the suitability of a new method of photo-ID based on the coding of the facial profiles according to the position and the shape of the scutes for green (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) using photographs from Reunion, Mayotte, and Mahe, Seychelles (Western Indian Ocean). We developed a database to manage photographs and sighting reports, using the images converted by visual inspection or "fingerprints". This method was designed to use photographs taken by local Scuba divers to identify untagged individuals foraging outside the reef barrier. Photographs of both flipper-tagged and photo-identified turtles or untagged individuals that were photographed several times when they were observed were used for the validation of the method. Analyses of 106 profiles of green and 132 profiles of hawksbill turtles facial profile pictures taken at the three sites studied have shown the effectiveness of the technique for individual identification and site fidelity studies of foraging habitats. Among the matching profiles, 94.4% profiles for greens and 78.3% profiles for hawksbills were found in the first position. The participation of scuba divers is a great opportunity to collect images over time and across a broad range of locations, allowing continuous and long-term studies. It is also a good way to increase public awareness for the conservation status of these endangered species.

A STUDY OF GREEN TURTLE FEEDING ECOLOGY BY MONITORING HEAD MOVEMENTS WITH AN ACCELERATION DATA LOGGER

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Behavioral observation for marine animals is more difficult than for terrestrial animals so there are many misconceptions about ethology, physiology and ecology of marine animals. Similarly, feeding ecology of sea turtles is not well known: for example when, where, and for how long they feed. A recent study developed a technique for monitoring feeding behavior of sea turtles using acceleration data loggers attached to the lower beak (Okuyama *et al*. 2009). In the present study, we modified this technique and attached the acceleration data loggers to the head and carapace of sea turtles to observe when, where and for how long they feed in the wild. We used three subadult green turtles (A: 49.2, B: 60.9, C: 55.3 cm straight carapace length) captured around Aragusuku Island, Okinawa, Japan. An acceleration data logger (M190-D2GT, Little Leonardo Ltd.) was attached to the head, and a speed/acceleration/depth data logger (W1000L-3MPD3GT, Little Leonardo Ltd.) was attached to the carapace, with a time-scheduled release system. Turtles were released near the area where they had been captured. At a scheduled time (A: 3 hours, B: 120 hours, C: 72 hours), data loggers were automatically detached from the turtles, and then popped up to the sea surface. As a result, we were able to retrieve the data loggers from two turtles (Turtle A and B). Here, we introduce results of this study.

*OCEANIC ISOSCAPES AND THE FEEDING ECOLOGY OF SEA TURTLES IN THE SOUTHEASTERN PACIFIC OCEAN: A STABLE ISOTOPIC ANALYSIS

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Sea turtles in the open ocean are extremely difficult to study and many aspects of their ecology remain unknown. The feeding ecology of sea turtle living in oceanic environments, for instance, has been rarely studied due to the difficulty in gaining access to individuals living in the high seas. One method that has proven effective for inferring sea turtle feeding habits is stable carbon and nitrogen isotope (δ15N, δ13C) analysis. This method allows to us to determine where in the food chain an individual is feeding and if the food resources are coastal or oceanic. However, to do so requires information about the stable isotopic signatures (i.e. isoscapes) of the habitats within which turtles live, and this environmental context has rarely been examined in previous stable isotope research on sea turtles. Because many sea turtles get captured in longlines, we decided to take the opportunity to study their foraging ecology in the oceanic waters off Peru, with access to animals gained via sampling turtles captured incidentally in artisanal and industrial longline gear. From 2002 to 2009, we collected a total of 138 skin samples from green, loggerhead, and olive ridley sea turtles incidentally captured during longline fishing sets off Peru. The fishing sets where sea turtles were captured targeted mahi mahi, *Coryphaena hippurus,* or sharks and spanned almost the entire Peruvian coast from the latitude 3ºS to the 18ºS (around 1,600 km). We also collected prey samples from the environment that include fish, mollusks, crustaceans, cnidarians, algae and *Macrocystis* sp. Samples of the different kind of baits used in longline fishing were also collected (Jumbo squid, *Dosidicus gigas,* and Chub mackerel, *Scomber japonicus*). The skin samples of sea turtles and samples from the pelagic prey were prepared following standard methodologies and subsequently analyzed in an isotope ratio mass spectrometer. The results provide insights about the foraging ecology of each turtle species, common prey, and overlaps or differences among species. We will also conduct tests to determine if there are geographic differences in the isotopes signals of sea turtles. This study will not only fill gaps in the foraging ecology of sea turtles in oceanic waters but also will determine the importance of longline baits in their diets.

USING DNA TO DETERMINE THE ORIGIN OF GREEN AND HAWKSBILL TURTLES FROM THE FEEDING GROUND OF MALAYSIAN WATERS

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Marine turtles are known to move extensively between nesting and feeding grounds, but in most cases, for example in Malaysia, it is not known which reproductive populations occupy a particular feeding habitat. Harvesting is a major threat to sea turtles; hence resolving stock compositions at feeding grounds is urgently needed to conserve these endangered species. This research aimed to identify feeding grounds in Malaysia and to identify the turtle stocks occupying each area using molecular DNA techniques. Locations of feeding grounds around Malaysian waters were identified and currently there are three sites suspected to be feeding grounds in Peninsular Malaysia (Redang Island, Bidong Island and Tioman Island) and five sites in Sabah (Sipadan Island, Turtle Islands Park, Tiga Island Park, Mengalum Island and Mantanani Island). Once feeding grounds were identified, samples of marine turtles from that particular area will be collected. Turtles were captured by SCUBA diving or snorkelling. Once captured, turtles were lifted up to the boat and samples were collected. The turtles were tagged, measured and examined for any injuries and ectoparasites before releasing them to the water. DNA Extraction was done using quick CTAB protocol. DNA samples were then amplified using TCR 5 & TCR 6 primers and sequenced. A total of 65 green and 4 hawksbill turtles were caught at Tun Sakaran Marine Parks and Sipadan Island, Malaysia. Sampling throughout Redang and Perhentian Islands will be conducted until in the end of 2010. The west coast of Sabah and Sarawak will be sampled in March to April 2010. Other than blood samples collected from the feeding grounds, we are also analyzing tissue samples donated by the Department of Fisheries Sabah from the sea turtle carcasses seized from the Hainan vessels in 2007. Preliminary results have shown that there are seven haplotypes (A2, A3, C3, C5,

CARU, D2, E2) detected among 65 green turtle samples which were previously identified by Moritz *et al*. (2002) for the Southeast Asian and Western Pacific green turtle. There were two haplotypes (H1 and H4) found in four hawksbill turtle samples. Twenty-six samples were identified as D2 (mainly from Malaysia and Philippines), 17 samples were identified as C3 (common in Southeast Asia), 14 samples were identified as A3 (mainly from Papua New Guinea, Micronesia and Australia), 4 samples were identified as C5 and two samples as CARU (mainly from Indonesia), and one sample identified as A2 and E2 respectively (mainly from Australia and Micronesia). Four samples of the hawksbill also from the STIP.

ALGAE, ANIMALS AND MARINE DEBRIS: GREEN TURTLE DIET IN THE SOUTH OF BRAZIL

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Green turtles, especially juveniles, are opportunistic foragers with tendencies to herbivory. Marine debris is frequently found in their diet and figures as one of the main threats to this species. This study provides descriptive detailed information on sea turtle diet with inferences on ingestion features. The stomach contents of fifteen stranded green turtles, collected by the Brazilian Sea Turtle Conservation Program (Projeto TAMAR) along the coast of Santa Catarina State, south Brazil, were analyzed. Strandings occurred from May 2008 and July 2009. CCL and CCW were measured and sex identification was also done when possible. Diet items were identified to the lowest taxonomic level possible, dry weight and volumes were obtained, and debris buoyancy was determined. Items comprising >50% of total content volume are assumed to be main diet items for that individual. *Codium* spp. (four species) was found in 60% of individuals representing main feeding item for one of them, *Sargassum* spp. (three species) was found in 47% of individuals always figuring as a complementary item and *Pterocladiella capillacea* was also ingested by 47% of the individuals and was the main feeding item for five. As these turtles stranded in poor health or dead these results should be cautiously interpreted. Turtles ingested cnidarians and ctenophores (53%), bivalves (40%), and amphipods and decapods (27%). Cephalopod beaks were found in three stomachs, and in qualitative analysis of three intestines, totalling 20 beaks. Four beaks were assigned to pelagic deep sea squids of the genera *Chiroteutis* and *Histioteutis*. Beak measurements allowed estimation of the squid's mantle length (8.6–10.9 cm). It is not clear if these ingestions are a result of predation or if turtles opportunistically foraged during cephalopods' mass mortality following spawning events. Although further studies are necessary, information on the location of these events might provide important insights on green turtle movements. Marine debris was in 87% of individuals, mainly plastic bags (73%) and fishery lines (60%). Hard and flexible plastic, rubber, styrofoam and human hair were also found. All presented positive buoyancy in sea water, suggesting that debris is not necessarily associated with benthic feeding but could also be ingested from the water column. Sea turtle diet studies are worthwhile tools for assessing behavior and feeding ecology. Sharing and compiling data should be encouraged in order to generate wider-scale approaches. Acknowledgements: 30th STS for Travel Grant awarded to GOL. Zaira Matheus and All Angle Images, Fernando de Noronha, PE, Brazil for logistical support. Projeto TAMAR is affiliated with ICMBio, co-managed by the Fundação Pró-TAMAR, and officially sponsored by PETROBRAS. We dedicate this paper to Fernando Dias Pazeto (in memoriam).

DIET OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) ON THE CONTINENTAL SHELF OF URUGUAY

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Larger juvenile and adult specimens of loggerhead turtles (*Caretta caretta*) are known to occur in the temperate coast of the Southwestern Atlantic Ocean (SWAO). The aim of this work is to evaluate the diet of loggerhead turtles on the continental shelf of Uruguay using gut contents from larger juveniles and adults stranded on Uruguayan coast (33°45'S – 35°01'S). After dissection (n = 52), esophageal, stomach and intestinal contents were fixed in 10% formalin and afterwards transferred to 70% ethanol. Contents were examined in the laboratory by washing through a 1 mm mesh sieve. Diet data were analyzed through frequency of occurrence, numerical importance and by the Index of Relative Importance (% IRI), using the conventional procedure and a novel Bayesian method. Relative biomass was calculated through weight mean of the prey's species, found in benthonic samples of the area. Overlap between animal groups was evaluated using specific overlap and general overlap (GO) indexes. Turtle sizes ranged from 52.2 cm to 114.6 cm carapace length (mean = 75.5, SD =12.3). Crustaceans and gastropods were the main food items (% IRI = 99%), where five species presented 97% of the % IRI ranked as follows: hermit crab, *Loxopagurus loxochelys* (% IRI = 38.1%, Credibility Interval = 26.9%–49.4%); spider-crab, *Libinia spinosa* (% IRI = 30%, CI = 21.9% to 37.7%); snail, *Buccinanops cochlidium* (% IRI = 18.3%, CI = 12.2% to 24.6%); black-snail, *Pachycymbiola brasiliana* (% IRI = 8.8%, CI = 4.6% to 15.7%); hermit crab, *Dardanus insignis*, (% IRI = 3.4%, CI = 2.1% to 5.2%). The diet between larger juveniles and adults was not different (SO = 0.998, p = 0.81). Different food combinations were observed between summer and autumn ($p = 7.8.10^{-15}$, $p = 1.4.10^{-5}$). The same five species were the most important prey in both seasons, but with different rank of importance. According to the GLMs, there was a seasonal effect on the abundance and occurrence of *P. brasiliana* in gut contents. It wasn't possible calculate the numerical importance of the fishes and therefore we only used the occurrence frequency for fishes in diet analysis. The most common fish species was the sable-fish, *Trichiurus lepturus* (O% = 17.3%). The analysis of the contents indicates that the studied area constitutes a feeding zone for *C. caretta*, the southernmost reported for the southwestern Atlantic. The loggerheads there mainly eat megaepibenthic and shallow megaendobenthic gastropods and decapods that inhabit muddy or muddy-sandy bottoms, between circa 10 to 50 meters. The four species of bony-fishes found are typical components of bycatch of bottom trawling fisheries in the Uruguayan coast. Three loggerheads contained fish remains and specimens of the small scavenger snail, *Buccinanops deformis*. We interpret these contents as the result of feeding on by-catch that reached the sea floor. The interaction with fisheries is a major source of mortality for (*C. caretta*) in the area. The interrelationship between fishing activities, foraging ecology and incidental mortality, can provide a basis for an ongoing interdisciplinary research to assist the conservation action plan for *C. caretta* in Uruguay.

*DIET OF OCEANIC LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN THE SOUTHWEST ATLANTIC OCEAN (SWA)

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The oceanic stage in the life cycle of sea turtles remains poorly studied and little is known about how they obtain a sufficient quantity of prey items in order to satisfy their development in the open ocean. The aim of this work is to assess the diet of loggerhead sea turtles (*Caretta caretta*) in the oceanic environment at the Southwest Atlantic

Ocean (SWA). Gut contents from early juveniles were collected from animals incidentally captured (n=59) by the Uruguayan pelagic longline fishery fleet (30.286°S – 37.2°S). Esophageal and stomach contents were fixed in 5% formaline and examined in the laboratory by washing through a 1 mm mesh sieve. Diet data were analyzed through frequency of occurrence, numerical importance and by the conventional Index of Relative Importance (%IRI) and a novel Bayesian method. GLM's were used to address the effect of variables on the diet. The turtles' size ranged between 44 cm and 67 cm of curved carapace length (mean = 57.1 cm, SD = 5.5 cm). Salps (%IRI = 81.4%, Credibility Interval = 70.05–85.69) and siphonophores (% IRI =12.5%, CI = 7.85–18.65%) were the most abundant items for oceanic juveniles. Thirteen other feeding items were found in the loggerhead guts, but in low frequency (% IRI <2%). Although amphipods were frequently registered (%O = 62.7%), %N and %V values (%IRI = 1.7%, CI = 1.3%–2.8%) were low. Pelagic fishes occurred in 10.2% of the samples and represented an important ingested volume (%V = 6.63%). In addition to prey resources, marine debris (%O = 45.76%), birds' feathers (6.77%), parasites (13.56%) and baits deployed by the longline fleet (72.88%) were also found in the diet. More than one bait was found in seven stomach contents (%O = 11.86), while one turtle reached up to six baits. According to the GLMs, there was no effect of latitude, sea surface temperature, carapace length, and seasons on the occurrence of feeding items. But, amphipods abundance in the diet was directly affected by siphonophore abundance. We propose two feeding strategies for oceanic loggerheads: (1) maintenance, with predation of gelatinous prey and (2) opportunistic, with predation of a diversity of food types in low frequency. Despite the fact that gelatinous organisms are usually classified as top predators in trophic networks with low relevance, reports on animals that feed preferentially upon them are rapidly increasing. Amphipods exhibit ecological relationships with diverse gelationous groups, main prey item of turtles, and may be used as a hydrological indicator of habitat use. The high occurrence of marine debris found in the stomach contents indicates that this can be an important threat to sea turtles in the pelagic environment, which may be underestimated due to the low stranding probability of these individuals. The results of this study show that the area off South Brazil, Uruguay and North Argentina constitutes a feeding ground for juvenile loggerheads with pelagic habits during their oceanic stage with preferences for epipelagic zooplankton consumption.

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*NATAL ORIGIN OF JUVENILE LOGGERHEAD TURTLES FROM FORAGING GROUNDS IN NICARAGUA AND PANAMA

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Our study estimates natal origins of juvenile loggerhead turtles (*Caretta caretta*) in coastal waters of Caribbean Nicaragua and Panama using Marcov Chain Monte-Carlo (MCMC) Bayesian mixed stock analysis of mitochondrial DNA dloop haplotypes. We generated sequence data from 73 blood or tissue samples of juvenile loggerhead turtles captured in foraging habitats in Caribbean Nicaragua and reanalyzed 45 juvenile loggerhead haplotypes from Panama. Due to differences in stock compositions between the two sites that cannot be explained solely on nesting contribution size, we investigated other possible factors contributing to these differences such as ocean currents and their influence on juvenile migration patterns. In addition, we considered the influence of oceanographic distance and animal size at each site. Ocean current models were used to determine their influence on differences between the stock compositions at each foraging ground.

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*STABLE ISOTOPES AND TELEMETRY REVEAL LIFE HISTORY DICHOTOMY IN JUVENILE LOGGERHEAD SEA TURTLES

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Variation in life history strategies within a population, such as differential habitat use, can have profound consequences for survivorship, stage duration, and time to maturity. We used satellite telemetry and a suite of

biological information to explore behavioral complexities in habitat use of juvenile loggerhead sea turtles (*Caretta caretta*). Identification of ecological factors associated with variation in marine turtles' movement patterns would provide important insights for intra-population phenotypic variation and help to guide conservation efforts. Turtles collected in an estuarine foraging ground in North Carolina, USA, exhibited divergent strategies migrating to either neritic or oceanic destinations after capture. We then attempted to characterize the variables underlying this variation in migratory destination through stable isotope analysis (SIA) of carbon and nitrogen ratios in blood plasma and red blood cells, and through analysis of sex, genetic haplotype, body size, and remigration records. Using multivariate logistic regression analysis, we determined that nitrogen isotope ratios and remigration tendency best predicted the migratory destinations of these turtles. We further explored the turtles' diet history during recent and protracted periods and compared their isotopic signatures to those of potential prey we collected in estuarine and oceanic habitats. While nitrogen ratios of oceanic turtles and prey were significantly lower than those of neritic turtles and prey, we found no difference in carbon ratios for either turtles or prey. Results of a Bayesian mixing model indicated that whereas benthic invertebrates dominated the recent diet of neritic turtles, pelagic prey items contributed substantially to the diets of oceanic turtles. A group of turtles with unknown migratory destinations had isotope ratios intermediate to oceanic and neritic turtles. Analysis of protracted diet composition via SIA of red blood cells reflected contributions from pelagic and oceanic prey for all turtle groups, indicating that all turtles fed in the pelagic zone during overwintering periods. Oceanic turtles likely inhabited open ocean regions during the winter, prior to entering summer foraging grounds, while neritic turtles may have occupied offshore areas at the edge of the Gulf Stream. Our results suggest that much of the life history complexity in this population of loggerheads may be mediated by foraging behavior, which may result in an extended juvenile stage for some individuals. This behavioral variation could have important life history implications among individuals, and thus could influence population dynamics.

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*STRUCTURE OF NEARSHORE ALGAL COMMUNITIES AND THEIR RELATIONSHIP WITH GREEN SEA TURTLE FEEDING HABITS AT A FORAGING GROUND IN THE CENTRAL PACIFIC

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A comprehensive examination of the foraging ecology of many species of sea turtles, specifically the availability of diet items and feeding preferences, is currently lacking. Yet understanding their capacity to impact ecosystems through foraging and habitat use is essential for developing recovery plans that incorporate not just individual threatened species, but protection of entire marine ecosystems. This study examines the foraging habits of green turtles (*Chelonia mydas*) at Palmyra Atoll, in the Line Islands of the Central Pacific Ocean. We also assess habitat characteristics of nearshore reef and lagoon algal communities utilized as foraging grounds by green turtles. We investigate species composition, diversity and relative density of marine algae at Palmyra Atoll. Furthermore, we assess the effects of some macro-scale habitat characteristics on the distribution patterns of algae. Our study focused on six shallow, nearshore reef flats and one shallow lagoon site where turtles are frequently sighted. Based on 209 quadrat samples from these seven sites, the dominant type of biological cover found on reef was multispecies assemblages of turf algae. The primary geomorphic structure of the majority of sites was made up of coral rubble and pavement. Overall, 30 species belonging to Chlorophyta (n = 12 species), Phaeophyta (n = 4), Rhodophyta (n = 11) and Cyanobacteria (n = 3) were identified. The green algae, *Cladophora* spp. and *Caulerpa* spp., and the red coralline algae, *Hydrolithon* spp., were the numerically dominant and most common genera along nearshore reefs. In contrast, an invasive species, *Acanthophora spicifera*, was dominant in the lagoon system of Palmyra. The effects of site (n = 7) on species richness and evenness did not vary among reef sites but did significantly vary between reef and lagoon systems ($F = 12.21$, $df = 6$, $p = 0.05$). A preliminary assessment of green turtle gastric lavage samples from animals sampled throughout the atoll (n = 23) identified a minimum of 29 genera of algae. The invasive algal species dominant in the lagoon systems, *Acanthophora spicifera*, was found in gastric samples from individuals at several sites. This invasive species was one of the most commonly consumed food items, followed by *Laurencia* and *Gracilaria* spp. Although results are based on small sample sizes, preliminary data indicate that turtles may preferentially feed on different species at different sites, and variation seen in turtle diet may at least partially be due to site variation in algal species diversity as measured by the Shannon diversity index. Several algal species not

identified in habitat surveys were identified in gastric samples, many of which were small epiphytic algae. Macro algae found in turf assemblages accounted for approximately 63% of the volume of samples. In decreasing order of abundance, the remaining food items consisted of other species of turf algae, typically epiphytic species (32%), parasites (3%), benthic substrate (1%) and animal matter (1%). Algal species richness and species evenness varied significantly between individuals ($p < 0.05$). Future studies including telemetry and stable isotope analyses will examine stage class feeding variation which will allow a more quantitative evaluation of the ecological function of sea turtles as consumers.

IDENTIFYING FORAGING BEHAVIOUR OF FREE-RANGING LOGGERHEAD TURTLES, *CARETTA CARETTA*, USING VIDEO AND 3-D DATA LOGGERS

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Studying foraging behaviour and ecology of sea turtles has been difficult because direct observation of free-ranging turtles is virtually impossible. Most sea turtle diet studies have been done by analyzing stomach and feces contents, reporting that adult and sub-adult loggerhead turtles (*Caretta caretta*) are benthic feeders ingesting a wide range of invertebrates, such as mollusks and crustaceans. However, it has also been reported that loggerhead turtles feed on gelatinous organisms. To examine the importance of such easily digested prey in their diet, an *in-situ* study is necessary. In this study, to characterize and estimate foraging events of loggerhead turtles under natural environment, 2 types of animal-borne recorders were used simultaneously: 3-D data loggers (3MPD3GT: Little Leonardo, Japan) to record turtle's three-dimensional movements, and video cameras (Crittercam: National Geographic Society) to record prey items. During 2007 and 2009, we attached recorders to 6 loggerhead turtles (SCL = 77.3 ± 5.2 cm), which were accidentally captured by fishing net set at Sanriku coastal water, where adult and sub-adult loggerhead turtles migrate for feeding. All turtles were released from Otsuchi Bay (39°20N, 141°56E). Within a few days, the recorders were automatically detached from the turtles and collected. A total of 113.5 hours of data (i.e. 25 hours of 3-D and video data, and 88.5 hours of 3-D data) were obtained. From 5 turtles, 70 foraging events were recorded by video and 3-D data. In 66 out of 70 events, turtles fed on gelatinous organisms. Foraging events occurred when turtles were actively swimming either at surface or in mid-water, at mean depth of 19.3 ± 9.7 m. Once turtles found the prey item, they gradually decelerated to approach the prey. In the present study, there was a limited duration of video data due to memory capacity. However, based on characteristics revealed by 3-D and video data, possible foraging events were identified from 3-D data. Our result showed that turtles foraged on a number of gelatinous organisms at the surface and in mid-water, suggesting that gelatinous organisms may be an important component of loggerhead turtle diets.

NOT JUST ANOTHER MIXED STOCK ANALYSIS: GREEN TURTLES OF ESPIRITO SANTO, BRAZIL

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In the Southwestern Atlantic Ocean, sea turtles are exposed to a myriad of threats including disease, fisheries bycatch, and industrial or coastal development, but are protected by effective conservation organizations. In Espírito Santo, Brazil, green turtles (*Chelonia mydas*) with a relatively high incidence of fibropapillomatosis tumors routinely strand in the vicinity of the state capital, Vitória, a highly urbanized area that encompasses the effluent discharge channel of a local steel plant. This is also a particularly interesting population because of its relative

proximity to the regionally important Trindade Island rookery, whose feeding grounds have not been convincingly identified to date. To investigate the population distribution of the at-risk turtles, we sequenced a segment of the mitochondrial control region (862 bp; n = 132). Eight mtDNA haplotypes were revealed, of which the most common were CMA-08 and CMA-05. Haplotypes CMA-06 and CMA-09 were each found in six individuals, and rare haplotypes CMA-03, CMA-10, CMA-23, and CMA-32 were also detected. Two kinds of "many-to-many" mixed stock analyses were carried out, taking into account or alternately disregarding source nesting population size. The analyses that included population size were more consistent with expectations. The same approach was taken with traditional MSAs ("one-to-many"), and the main differences between the "one-to-many" and "many-to-many" results are reported. We recommend caution when employing different mixed stock analysis methods, and emphasize the importance of exploring alternate ways of investigating the origins of mixed stocks, including the analysis of longer DNA segments. These data will provide insight into population isolation and conservation priorities necessary to establish whether areas should be managed as independent units or as regional populations, and will clarify questions of scale in conservation and management, providing a scientific basis for conservation prioritization.

*DETERMINING POPULATION STRUCTURE OF JUVENILE GREEN TURTLES USING LAPAROSCOPY AT MANTANANI, SABAH, MALAYSIA

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In Southeast Asia virtually all knowledge about sea turtle biology is derived via nesting beach studies. This study investigated life-stage parameters for a foraging population of immature green turtles, *Chelonia mydas,* in shallow-waters (0–3 m) off the northwest coast of Borneo, Malaysia, to elucidate a significant portion of the at-sea life stage component. Laparoscopic examination of more than 100 individuals over three years provided information on sex ratios and maturity. Size classes suggested all animals were juveniles, and ranged from 38 to 80 cm CCL. Laparoscopic examinations of the gonads confirmed that all individuals were immature, with a sex ratio of 1 M : 4 F. These initial data on foraging green turtle population structure and dynamics are of use for life-stage population models and turtle management and recovery planning. Capture-mark-recapture data provided new information on localised movements between captures, residency period and growth, which averaged 3.6 cm yr^{-1} over 12–24 month periods.

*SIZE DISTRIBUTION OF GREEN TURTLES (*CHELONIA MYDAS*) IN THE GULF OF VENEZUELA – A COMPARISON OF THREE DECADES OF RESEARCH

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For populations of highly migratory and threatened species, information is required not only from reproductive individuals and zones, but also from feeding grounds and/or migratory routes. This is particularly needed for sea turtles because the defining characteristics of their life cycle (slow to mature, long lived, highly migratory) mean that their breeding and feeding sites are spatially separated. To evaluate the fluctuations and variations in size distribution of green turtles (*Chelonia mydas*) in the Gulf of Venezuela (GV), a comparison of three decades (1980s, 1990s and 2000s) of research was carried out, with more than five investigations conducted in the study area. From 2007 to 2009, we collected a total of 49 carapace measurements of stranded green sea turtles which had been captured or exploited in several localities on the coast of the Gulf of Venezuela. For this period, we obtained average sizes of 42.35 cm CCL, indicating that most individuals were juveniles (69.39%), followed by subadults (24.49%) and lastly, adults (6.12%). In the 1980s, size classes of green sea turtles in the GV showed a tendency toward sub-adult individuals larger 50 cm CCL (representing 83.7%, n = 77). Then in the early 1990s, this proportion varied

considerably, leaning toward the larger stages with sizes between 60 and 90 cm CCL (n = 166). In the early and mid 2000s, most individuals were subadults with sizes between 40 and 80 cm CCL (56.94%, n = 119). The results of this study suggest that green turtle populations in the GV fluctuate over the years. Such variations may be due to various anthropogenic pressures and environmental changes occurring in this important feeding area. Similarly, it is important to highlight the possible influence of recruitment of juveniles from conservation projects with high success rates in the Caribbean region. It is necessary to conduct more studies (such as genetic analysis and abiotic data collection in the study area) focused on determining the reason for these fluctuations.

PHOTO ANALYSIS OF SEA TURTLES BY UNDERWATER PHOTOGRAPHS TAKEN BY DIVERS

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Previously, distribution of sea turtles has been investigated by documenting bycatch or stranded sea turtles. However, these methods are affected by biases such as differences in bycatch rate, mortality, ocean currents, research effort, and so on. Thus, other methods are needed to clarify sea turtle distribution. In this study, we focused attention on sea turtles observed by recreational divers. Many divers have a penchant for diving with their cameras and they usually take photographs when they come across a sea turtle. We attempted to clarify species composition, distribution, and timing of the appearance of sea turtles near the Japanese coast by analyzing photographs collected from divers. This is a useful method to clarify turtle distribution, though there is bias in when and where dives are conducted. From April 2008 to September 2009, we assembled photographs of 251 individual turtles. From these, we identified 206 green turtles (*Chelonia mydas*) (82.1%), 34 hawksbill turtles (*Eretmochelys imbricata*) (13.5%), 9 loggerhead turtles (*Caretta caretta*) (3.6%), and 1 olive ridley turtle (*Lepidochelys olivacea*) (0.4%). Green turtles were the most common species documented around the Japanese coast. However, it should be considered that they inhabit reefs, which are also preferred sites for divers. Green turtles were photographed on the Pacific coast, from southern to central Japan, and two were photographed in the Japan Sea. It was in the Ryukyu archipelago that green turtles were photographed most: 134 of 206 sightings (65.0%), with 62 sightings concentrated in the Kerama Islands. The Izu Islands and the Kii Peninsula followed, with 20.4% and 11.2% of sightings, respectively. In the Kerama Islands, there was a distinct seasonality in sightings: 12 turtles were photographed in June and 15 in November. Locations were Mikura-jima and Hachijo-jima in the Izu Islands, the southernmost area of the Kii peninsula, and the middle of Honsyu Island in the Japan Sea. Hawksbill turtles were photographed only in the Ryukyu archipelago and were seen most frequently in the Kerama Islands (79.4% of sightings). Nine loggerhead turtles were seen in the Ryukyu archipelago and Yakushima Island. Olive ridleys were seen in Amakusa, West Kyushu.

*MONITORING OF GREEN (*CHELONIA MYDAS*) AND HAWKSBILL (*ERETMOCHELYS IMBRICATA*) SEA TURTLES AT A NEARSHORE FORAGING AREA IN THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS, WESTERN PACIFIC USING AN INDIGENOUS APPROACH

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Estimates of nearshore sea turtle numbers in foraging areas around the Commonwealth of the Northern Mariana Islands (CNMI) have typically utilized methods involving tow or transect surveys performed by scuba divers or snorkelers. While these methods provided insight into turtle demographics within the region, Kolinski *et al*. (2004) suggested that estimates would benefit if combined with long-term mark-recapture studies. In this study we used an indigenous hand-capture approach to perform surveys in a nearshore foraging area. Indigenous hand-capture

technique refers to using traditional free-diving and hand-capture skills learned from a cultural knowledge base (such as traditional ecological knowledge from Micronesian village elders) to capture turtles. This traditional method was reliable in CNMI as the water was clear, visibility was good, and use of nets or rodeo technique was not feasible. Ninety-eight green turtles (*Chelonia mydas*) and six hawksbill turtles (*Eretmochelys imbricata*) were indigenously hand-captured during 139 survey hours near the islands of Saipan, Rota and Tinian, CNMI from August 2006 to August 2009. Seasonal yearly effort has been exerted at Saipan, while rapid assessments were conducted in July 2009 for Rota and Tinian. Upon capture, turtles were measured, weighed, dually tagged (metal flipper tags externally and passive integrated transponder [PIT] tags internally), skin biopsied, photographed, and then released. Turtles had a mean curved carapace length (CCL) of 53.5 cm ± 9.9 SD (n = 104), mean curved carapace width of 48.9 cm ± 9.1 SD (n = 104), minimum straight carapace length (SCL) of 33.6 cm (n = 76), maximum straight carapace length of 74.1 cm (n = 76), and mean weight of 20.7 kg ±13.2 SD (n = 78). Curved carapace lengths and widths were measured throughout the project period, while weight, straight carapace lengths and widths were only measured since October 2008. Juvenile size class (CCL < 70 cm; SCL < 65) accounted for 91.3% of turtles captured, while the remaining 8.7% were sub-adults (CCL 70–86 cm; SCL 65–80 cm). This is the first study of this size within the CNMI region to report on hand-captures producing actual (non-estimated) morphometric data on a foraging population of green and hawksbill turtles. Thus, this study serves as a preliminary description for population structure and size class composition for green and hawksbill turtles in CNMI regional waters. Furthermore, the approach used here reflects the inherent value of traditional ecological and scientific knowledge integration in sea turtle research and management in Micronesia and promotes conservation of indigenous knowledge.

ANALYSIS OF DIGESTIVE SYSTEM CONTENTS FROM STRANDED LOGGERHEAD TURTLES IN THE KANTO AREA, JAPAN

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The Tokyo University of Marine Science and Technology (TUMSAT) Sea Turtle Research Collegium has been collecting and analyzing digestive system contents from stranded loggerhead sea turtle since 2003. From samples collected, we have focused on anthropogenic debris, shells, ascidians, fishes, algae, and crustaceans. When analyzing those contents, we have assumed that anthropogenic debris does not necessarily lead to a turtle's death. Therefore, we discuss which contents can give us a clue about causes of stranding of loggerheads in the Kanto area. Here we present our first analysis of digestive system contents related to emergence rate, month, and the Koroshio Current. Our goal is to determine why loggerhead turtles strand on beaches in the Kanto area by analyzing digestive system contents. Acknowledgments: the authors would like to thank the NPO Everlasting Nature (ELNA), without whose full cooperation this research could not have been conducted.

EFFECT OF BITE FORCE TO PREY SELECTION OF LOGGERHEAD TURTLES (*CARETTA CARETTA*)

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Loggerhead turtles, *Caretta caretta*, are known to change their diet as they grow. However, the mechanism which triggers this change in diet remains poorly understood. It has been reported that they prey on gelatinous organisms in their pelagic stage, whereas in their coastal stage they prey on more nutrient-rich benthic organisms, such as crabs and snails. Since benthic organisms are harder than gelatinous organisms, it can be hypothesized that increased development in bite forces affect prey selection. In this study, prey items and bite forces of loggerhead turtles were examined to discuss this hypothesis. The study was conducted at northern coast of Japan, Sanriku coast, which has recently been demonstrated to be a summer foraging area for immature and mature loggerhead turtles. Loggerhead turtles accidentally caught by local fishing nets were transferred to the International Coastal Research Center, the University of Tokyo (39°21’05N, 141°56’04E). Each turtle was kept in a tank for a few weeks to collect feces. During this time, bite force measurements for each turtle were collected by using a bite apparatus that used a

piezoelectric force transducer (Kistler). When dead turtles were reported, gut contents were collected. During 2006 and 2008, prey items of 33 turtles (SCL = 71.2 ± 7.1 cm) were identified from feces and gut contents, and bite force of 33 turtles (SCL = 69.8 ± 7.2 cm) was measured. Prey with hard tissues (e.g. sea urchins, conchs) was only detected from large turtles (SCL > 69.1 cm). Bite force was positively correlated to SCL (Spearman's rank correlation, = 0.72, $p < 0.05$), and the maximum bite force recorded was 1548.3 N. Our results suggested that diet of small turtles might be constrained by small bite forces.

BRAINSTORMING ABOUT LOGGERHEAD SEA TURTLES FROM A CONCHOLOGICAL ASPECT

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Since 2003, the Tokyo University of Marine Science and Technology (TUMSAT) Sea Turtle Research Collegium has been performing research on digestive system contents of stranded loggerhead sea turtles in the Kanto area, Japan. This work was carried out with the assistance of Everlasting Nature (ELNA). Here we focus on and discuss shell samples from those contents. Most of the shell samples were from organisms which live in the sandy seabed and it can be assumed that loggerhead turtles feed in similar areas. Two possible patterns of loggerhead feeding behavior can be considered: feeding on nocturnal shells and feeding regardless of the time of day by hunting for shells living inside the sand bed. At first, since many samples of sea snails were collected which come out of the sand only during the nighttime, loggerhead turtle nocturnal foraging was suspected. Then samples of bivalves which habitually bury themselves in the sand were collected, lending support to the hypothesis of infaunal foraging. By analyzing shell samples, many hypotheses can be put forward but sample size is still small and there are many obscurities. In the future, we would like to continue the research by adding a geographical factor and taking the difference between the two sexes into consideration.

*A BETTER LOOK AT MITOCHONDRIAL DNA REVEALS VAST GENETIC VARIATION IN MEDITERRANEAN GREEN SEA TURTLES (*CHELONIA MYDAS*)

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The genetic structure of the endangered green sea turtle (*Chelonia mydas*) population along the Mediterranean coastline of Israel was studied for the first time. Sequence analysis of a 556bp fragment from the mitochondrial DNA (mtDNA) control region revealed the expected poor variation. The most common haplotype, CM-A13, was observed in all but two individuals. The other two haplotypes, which were found in two turtles washed ashore, are new, and differ from CM-A13 by a single point mutation each. To search for additional variation we designed several primers for PCR and sequencing of the AT reach 3' region of the variable region. We found a unique variable pattern that consisted of 4 AT repeat segments with varying numbers of repeats in each segment. We could therefore construct a 4-digit haplotype barcode for each mtDNA sequence. The seemingly invariable Mediterranean population has 31 different haplotypes. Previous studies and observation suggested that there are only 8–10 nesting females along the Israeli shoreline. We were able to find 10 different haplotypes for the nesting females and can now genetically identify each of them for conservation and controlled reproduction purposes. A corresponding approach for specific identification of the nesting females using genomic Short Tandem Repeats (STRs) failed due to a high polyandry incidence. The current approach combines the advantages of high polymorphism on one hand and a maternal lineage on the other hand. This new haplotyping approach was informative in an Atlantic sea turtle but not in sea turtles of Pacific origin since they do not have these four defined repeat segments. Most of the sea turtles that were washed ashore on the Israeli beaches had different haplotypes from those of the nesting females. These findings support our understanding that green sea turtles travel long distances, probably in order to maintain

high genetic variability. We believe that the new genetic analysis method that we have developed will serve as the new haplotyping standard for green turtle population research in the Mediterranean as well as around the world.

MALE LOGGERHEADS AT A FORAGING AND DEVELOPMENTAL HABITAT IN ALBANIA

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Artisanal fisheries at Patoku, Albania, have been monitored for two summers (2008–2009) as part of MEDASSET's ongoing conservation programme in the Eastern Mediterranean. Researchers have measured and newly-tagged >245 loggerhead turtles and 1 juvenile green turtle. Most (99%) were taken from stavnike fish-traps (a type of pound-net) and a small number were caught in gill-nets. Male loggerhead turtles accounted for 27% of the total bycatch (23 adults and 43 adolescent males). As an indicator of the stage of sexual development three measurements were recorded from the tail: i) distance from posterior margin of plastron to midline of cloacal-opening (Plas-clo); ii) total tail length (TTL); iii) distance from tail-tip to the posterior margin of the carapace (+/-cara). Turtles were allocated into 10-cm size-classes based on CCL (curved carapace length). Adult males are easily-recognisable – the tail extends well beyond the carapace margin – but adolescent males also were identifiable: the tail thickens proximally and then extends distally beyond the carapace. All turtles were measured; the smallest loggerhead showing definite tail development had a CCL=52 cm. The statistical differences in all three tail measurements (and CCL and CCW) were highly significant between adult and adolescent males. The duration of adolescence is probably considerable. Limpus determined this from laparoscopic examination of the gonads of turtles but laparoscopy was not an option at Patoku. We found that there was an overlap in size-classes between the smallest adults (CCL=68.5 cm) and the largest adolescent CCL=74.5 cm. It is unclear how many years of growth this represents. Comparing data from other geographical populations was not helpful: Mediterranean loggerheads are noticeably smaller than those reported from Australia and the Western Atlantic. Limpus reported CCL=96.0 cm juveniles. At Patoku our largest turtle was CCL=85.0 cm – an adult male in breeding condition (de-keratinised plastron and highly-visible penis). Amongst the intra-annual recaptures were several males, indicating that they remained foraging benthically in local waters for some months. Nesting has not been reported from Albania, and so this congregation of males is curious (and not en route to known nesting sites): are adult females also present? Why are there so many adolescent males at Patoku? Green had observed adolescent males in attendance during *Chelonia mydas* copulation at Galapagos so perhaps there is a social-facilitation process whereby the younger turtles learn from the reproductive males as well as trying for opportunistic sex. Either way it appears that Drinit Bay is a developmental habitat, at least for male loggerheads, and is perhaps even a mating area. Both males and females remigrated occasionally to Patoku: altogether 21 turtles were recaptured in one or more years, since tagging began in late 2002. Albanian waters form part of a succession of habitats for some loggerheads, and less-commonly for *Chelonia mydas*. The Patoku turtles came mostly from two fish-traps, but as other fisheries also occur in the bay the number of turtles using Drinit Bay is probably substantially higher, because it seems unlikely that every turtle foraging locally would enter one of the traps. This research is ongoing.

FIRST REPORT OF THE CRAB *CALLINECTES* SP. AS A DIET ITEM OF THE OLIVE RIDLEY TURTLE (*LEPIDOCHELYS OLIVACEA*)

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The olive ridley turtle, *Lepidochelys olivacea,* is a circumtropical species, distributed along the Caribbean from Venezuela to Bahía, Brazil. The principal threats that affect these turtles are high nest poaching and inwater bycatch. In Venezuela, *L. olivacea* has been catalogued as an Endangered Species since 1996. The foraging habitats for adult olive ridleys usually correspond to shallow waters with clay substrates, near estuaries. Olive ridleys are opportunistic animals that feed mainly on fishes, crustaceans and other small invertebrates. The Gulf of Venezuela (GV) constitutes an important feeding ground for the five sea turtle species reported for our country. The least abundant is the olive ridley: to date only four skeletons have been found to corroborate its presence and many ecological aspects remain unknown, especially their role within the GV's territorial waters. In order to contribute information about the olive ridley's feeding habits, we described the items found in the stomach and intestinal content from an adult *L. olivacea* found dead in a fishing port, which had been captured in the month of June in Porshoure, Alta Guajira, Gulf of Venezuela. We performed a longitudinal dissection of the digestive tract, preserving the content in 70% ethanol. Structures were separated and identified according to their characteristics, classifying them up to finest possible taxa. Total volume was determined by the water displacement technique. All of the structures (100%; 1005 ml) present in the content corresponded to individuals of the blue crab (Genus: *Callinectes*), based on the consistency, shape and color of the pieces. The size of the structures and the presence of eggs suggest that the content constituted mainly adult crab individuals. Previous studies have reported that the five species of *Callinectes* congregate during reproductive seasons (April–June) in saltwater-influenced zones such as the Gulf of Venezuela, which is the ideal ecosystem for this behavior. These considerable population abundances can be evidenced by the total representation in the stomach and intestinal content. Some studies report that olive ridleys feed on different crab species, however the current study represents the first report of *Callinectes* sp. as diet item of *L. olivacea*, corroborating likewise the benthic feeding habits of this species. Therefore this work pioneers knowledge of the feeding habits of olive ridley turtles in Venezuela.

*PRELIMINARY LIST OF SPONGES (PHYLUM: PORIFERA) DISTRIBUTED ALONG THE GULF OF VENEZUELA AND ITS RELATIONSHIP WITH THE FEEDING HABITS OF HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*)

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The phylum Porifera is one of the most diverse invertebrate groups in marine and coastal ecosystems, in terms of species and ecological roles. Likewise, hawksbill turtles (*Eretmochelys imbricata*) play an important part in the modeling of coral reefs, through the predation of sponges in these habitats. Among the principal components found as items in the diet of hawksbill turtles are ascidians and sponges (mainly *Chondrilla nucula* and *Geodia neptuni*). The Gulf of Venezuela (GV) is characterized by its high productivity, due to the diverse oceanographic characteristics and marine and estuarine environments. The GV presents an area of great biodiversity, with juvenile, subadult and adult hawksbill turtles among the observed species. The heterogeneity of environments and oceanographic conditions can favor the existence of associations between the sponges and present habitats such as

mangroves, seagrass *Thalassia testudinum* banks and rocky reefs. Although these associations are possible, the composition and distribution of the sponge communities, as well as the association with other marine species and the threats to the habitats, still remain unknown, increasing the necessity of starting studies that include the biology and ecology of porifers in this area. The objective of this study is to develop a preliminary list of the sponges distributed along the ecosystems of the GV and to study the relationship between sponge presence and the feeding habits of the hawksbill turtles. We conducted a random sampling in three localities of the Alta Guajira (Cocinetas, Punta Perret and Kazuzai) in order to photodocument the sponges associated with the different ecosystems. Tissue samples were preserved with Ethanol (70%) and subsequent identification was carried out in the laboratory, employing 10% hypochlorite and using identification keys of spicules and spicular arrangement in order to classify the sponges up to the minimum possible taxa. The preliminary results indicate the presence of 15 morphotypes belonging to 6 sponge orders in the three study areas. We identified 8 genera and 3 sponge species which represent the first records for the GV (*Chondrilla caribensis* previously called *C. nucula*, *Geodia gibberosa* and *Haliclona tubifera*). The preliminary association found of sponges with substrates such as seagrass beds, rocky reefs, coral reef patches and mangroves suggests that the distribution of the species is delimitated to specific habitats and emphasizes the importance of these organisms in the modeling of marine and coastal ecosystems. The presence of two sponges described as important components of the hawksbill's diet is of special interest: *Chondrilla caribensis* was found associated with seagrass beds and rocky reefs in two geographically distant zones (Punta Perret and Kazuzai), whereas *Geodia gibberosa* was distributed only in seagrass beds (Kazuzai). There are several records of the presence of *E. imbricata* individuals in these localities, suggesting that the GV presents potential ideal habitats for the foraging and feeding of this species. The results from this study reaffirm that the GV is an area of great ecological value in terms of biodiversity including a variety of habitats that allow the settlement of marine invertebrates and the feeding of marine turtles.

HEALTH & PHYSIOLOGY

THE PREVALENCE AND HISTOLOGICAL CHARACTERISATION OF STRUCTURAL ABNORMALITIES IN LOGGERHEAD SEA TURTLE HATCHLINGS (*CARETTA CARETTA*) FROM WEST AUSTRALIAN NESTING SITES

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Six of the seven species of marine turtles occur in Australian waters. The loggerhead, which has been listed as endangered by the World Conservation Union (IUCN 2006) and the Australian Protection and Biodiversity Act 1999 (EPBC Act) is one of three species of marine turtles breeding in Western Australia (Prince 1993) and is the focus of this study. To date, there have been no published studies on hatchling success or causes of hatchling failure in the nesting populations of Western Australian loggerhead turtles. In particular there is no information in regards to how gross abnormalities and abnormal histopathological findings may impact hatchling success. Therefore, the main purpose of this study is to identify and describe the normal histology of loggerhead sea turtle (*Caretta caretta*) hatchlings from nesting sites in Western Australia. It will be used to identify gross anatomical deformities and histological abnormalities and attempt to relate abnormal findings with failure to hatch or emerge. Gross abnormalities will be classified into 8 recognised body systems. Where possible, correlation of the identified histological and gross abnormalities with environmental factors such as nesting temperatures identified from studies conducted by Dr Sabrina Trocini will be made. This study will utilise loggerhead sea turtle hatchlings that were unsuccessful in either hatching or emerging from the nest. The control group will utilise those hatchlings that were 'successful' in emerging from the nest but were predated by ghost crabs while traversing the beach. A second control group of hatchlings that have been artificially incubated under controlled conditions will also be examined. These hatchlings are part of an independent study and as such will be euthanized as part of that project. All hatchlings have been fixed in buffered formalin 10%. No fresh tissue will be collected. Study groups: 1. Wild control: hatchlings that have successfully emerged from the egg and the nest however were predated while attempting to reach the water. 2. Artificial control group: hatchlings that have been artificially incubated for other research purposes. 3. Group 2: hatchlings that did not successfully emerge from the egg. 4. Group 3: hatchlings that did not successfully emerge from the nests. A complete necropsy examination will be performed on 20 turtles from each control group and 50 turtles from Group 2 and 3. A grading system will be formulated to correlate the identified abnormalities with their possibility of affecting hatching/emerging success. Tissues from hatchling loggerhead sea turtles (*Caretta caretta*) that were not successful (deceased) will be collected for histological examination. Computed Tomography utilising the micro CT technology at the University of Adelaide will be performed on 5 hatchlings from the artificially incubated hatchlings, 5 juvenile hatchlings and 15 hatchlings from Group 2 and 15 from group 3 with severe musculoskeletal deformities. Comparisons will be made between the normal and abnormal hatchlings.

MICROBIAL PENETRATION THROUGH EGGSHELLS OF THE GREEN TURTLE *CHELONIA MYDAS* UNDER NATURAL CONDITIONS AT RAS AL-HADD, OMAN

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Green turtles are exposed to different habitats during their migrations in the Indian Ocean, Arabian Sea and the Arabian Gulf. Fresh eggs were collected at random from different nests during June–October. Microbial deterioration of the eggs was studied. Most of the eggs were contaminated with bacteria and fungi. Scanning Electron Microscopy (SEM) examination revealed that bacteria and fungi are capable of penetration through the eggshells and caused massive deterioration which may hinder the embryonic development during the process of incubation.

SURGICAL EXTRACTIONS AND TREATMENT OF INJURIES CAUSED BY FISHING HOOKS AND LINES IN THE DIGESTIVE TRACT OF SEA TURTLES: CASE HISTORIES FROM 2005 TO 2009

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The longline is a fishing system widely used in the Sicilian Channel and is the cause of high mortality for sea turtles. Of 1,170 loggerhead turtles referred to WWF Sea Turtle Rescue Centre of Lampedusa in the past five years, at least 288 had lesions in the digestive tract resulting from the ingestion of hooks and lines. 213 cases showed a hook lodged in the wall of the oesophagus and the fishing line protruding from the rhamphotheca, while in the remaining 74 cases one or more hooks were detected in the stomach or intestine, with monofilament lines that occupied large stretches of the digestive tract. It is known that the surgical approach for the extraction of hooks from the oesophagus is relatively easy, while surgery of the lower digestive tract is certainly more challenging and further complicated by the serious injuries that hooks and lines often cause in the stomach and intestine. This study describes the surgical techniques used for extraction of hooks and lines from the stomach and intestine and reports the results obtained in relation to the type and severity of lesions found in 74 *Caretta caretta*. 24 turtles had a hook with a short line in the stomach and removal was easily achieved with the surgical approach through the soft tissues of the left axillary region. In 23 cases the surgical approach was via the soft tissues of the inguinal region (16 right and 7 left) to remove fishinglines that extended through the entire upper digestive tract. In the remaining 27 cases multiple surgical approaches (cervical and inguinal or axillary and inguinal) were performed to remove hooks lodged in the oesophagus or stomach, but where the longlines had traversed the entire digestive tract. In the 50 operations involving longline extraction, the intestine was exteriorized gradually from the inguinal approach and line was cut into segments and extracted through small multiple enterotomies (from 2 to 4) performed at regularly-spaced intervals along the anti-mesenteric margin. In 34 cases single or multiple intestinal lacerations were detected, caused by the pull of the lines; these were sutured progressively. In 5 cases, because of severe lacerations, it was necessary to perform an enterectomy of a long section of small intestine and subsequent termino-terminal anastomosis. Of the 74 operated turtles, 23 died after 4–12 days post-surgery as a result of intestinal lesions and severe debilitation, the remaining 51 made a complete recovery and were released 15–40 days after surgery. These data confirm that in case of interaction with longline fisheries the greatest danger is caused by the ingestion of lines that prevent the turtles from eating and rapidly cause serious damage to the bowel wall. However, in all cases where hooks, and/or line, have been ingested, it is imperative that extraction of these foreign bodies proceeds without delay, according to the most modern techniques of anesthesia and surgery, to maximise the chance of recovery. Acknowledgements: The first author wishes to thank the Sea Turtle Symposium and all the generous donators for financial support.

RESULTS OF SEA TURTLE ACUPUNCTURE RESUSCITATION PILOT TRIAL AND THE TORTUGA REVIVAL DEVICE

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Is it possible to revive stranded dead-appearing sea turtles, turtles in coma from head injuries, or turtles that have recently drowned? The answer is yes. The question is when to attempt to revive them. If they are stranded, there is probably some underlying pathology that you should be prepared to treat after you revive them. At Australian Seabird Rescue, their results were 4 revived out of 13 attempts, and 1 survived long term. However, these were turtles otherwise declared dead. At South Carolina Aquarium, acupuncture and epi. and doxapram were used to temporarily revive a few loggerheads that were declared dead. At Xcaret, Mexico, 2 loggerheads have been revived long term after being in coma from head injuries. The first, on i.v. over 3 months, was not eating or diving – just floating. She began moving during the first treatment and within a week began eating; over a few weeks she was

diving and acting like a normal turtle. The second loggerhead responded to acupuncture, beginning with slow reactions, and made good progress. At Le Reunion, France, 2 loggerheads were resuscitated successfully and released after being submerged, caught by hook. Pilot results thus far have had a 25% revival rate (short term) for beached, dead-appearing turtles, a 100% revival rate for coma from concussion, and a 100% revival rate after coma from forced submergence. The positive results of the small trial (16 turtles) suggest the need for a larger full scale controlled trial. Shrimp trawling is one of the greatest causes of sea turtle mortality throughout the world. The S.T.A.R. protocol was originally designed by Phil Rogers M.S.R.V.C. and myself to revive turtles in shock/coma for only a few hours due to being submerged by trawler nets or longline fishermen. Acupuncture at 1–3 specific points has been used by clinicians to successfully revive comatose humans, horses, dogs, cats and other species. The response is usually within 1–10 minutes. National Marine Fisheries Service compiled the results of 7 research projects spanning 12 years during which 4,397 turtles were caught in trawler nets. For most tow times, there were more comatose than dead turtles. It is assumed that a sea turtle returned to the sea in coma will die. Given the feedback regarding training laymen to use needles to resuscitate sea turtles aboard trawlers, a dime sized solar powered 10 hz microamp generator has been developed by myself and Joe Randolph of Randolph telecom. It is working in human trials and rapidly having the desired physiologic effect when used at acupuncture points on the ear. This device would be placed just below the turtle's nostrils at the philtrium – the main sea turtle emergency point. As easy as putting on a bandaid. Human testing began in early October 2009. We have had a 100% success rate and results that outperform our clinical microcurrent stimulators. Thanks to Karen Comstock and Casatortuga for believing in the project and funding the early research and development, and to Dennis Caldwell for the artwork and graphic design.

*THE SPIRORCHIIDAE TREMATODES INFECTED IN STRANDED GREEN TURTLES *CHELONIA MYDAS* IN TAIWAN

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In order to understand the infested status of spirorchids in the stranded green turtles, *Chelonia mydas,* in Taiwan, the appearance of spirorchiidae trematodes in the circulatory system of green turtles in Taiwan was determined. Twenty-three stranded green turtles, mostly subadults, were necropsied between 2007–2009. Although flukes were observed in 9 turtles (39%), more than half of the stranded ones were infected by the eggs of spirorchids. Three species of spirorchid were identified: *Leardius learedi*, *Hapalotrema postorchis* and *H. mehrai*. Among them, *L. Learedi* is the most common (78%), followed by *H. mehrai* (67%), and *H. postorchis* (only 20%). Results of this study showed that the spirorchid trematodes should be the epidemic diseases of green turtles in Taiwan.

ULTRASTRUCTURAL FEATURES RELATIVE TO THE DEVELOPMENT OF RETINA DURING DIFFERENT STAGES OF EMBRYOGENESIS IN GREEN TURTLES *CHELONIA MYDAS* AT RAS AL HADD

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This study was conducted to examine the ultrastructural features of the green turtle (*Chelonia mydas*) retina during different stages of embryogenesis by electron and light microscope techniques. Examination of the retina showed that the ganglionic layer was developed first followed by bipolar and photoreceptor layers. The eye cup was completely formed on day 14 of incubation; however, no differentiation of photoreceptor or bipolar layers was observed. The ganglionic layer first appeared on day 14 and reached development by day 19. The bipolar layer first appeared as an undifferentiated layer on the same day. At the same time, the inner plexiform region made its first appearance on day 28. The bipolar layer was clearly differentiated with the appearance of outer plexiform region. The photoreceptors began to appear, but they were not fully differentiated at this stage. They were fully differentiated by day 32 of incubation. There was no specific pattern in the distribution of the photoreceptor layer's components (rods and cones). Between days 32 and 40, the retinal layers showed specific differentiation. However,

after day 40, there was a rapid proliferation and differentiation of the retina and by the time of hatching, the retina was fully formed.

EPIBIONTS OF THE MARINE TURTLE *LEPIDOCHELYS OLIVACEA* THAT NESTS IN THE COAST OF JALISCO, IN THE MEXICAN CENTRAL PACIFIC

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The big marine vertebrates such as the cetaceans and the turtles constitute an excellent habitat and substrate for many invertebrates, called epibionts. From the ecological point of view, the main relationship that settles down between colonies of some hydrozoos and barnacles and the marine turtles is the use of its corporal surface, as much in skin as in shell, as a substrate of larval establishment dispersion and obtaining food. In an alternating way, the cycle of life of these turtles can indicate specific conditions of the environment where they develop, which is useful as a bioindicator. In the specific case of the marine turtles, these constitute an excellent substrate for a great variety of invertebrates, and in many occasions, of vertebrates such as the Remora (*Remora remora*), and algae, mainly chlorophytes – making the turtle like a true marine ecosystem. Therefore it is common to find different species living on the shell and on the skin of the turtles. Some species associated with turtles present a unique relationship since they only exist on this host type; it has been demonstrated that some organisms can give us indirect information about biological aspects that we have not been able to be observe in these turtles, such as migratory routes and aspects of their cycle of life. In Mexico, few works have focused on the study of the parasites of marine turtles, particularly in the turtle olive ridley, *Lepidochelys olivacea,* that is one of the most representative species and of wide distribution in the national and international environments and that arrives to the beaches of Jalisco each nesting season. The objective of this study was to provide information about epibiont diversity found on the marine turtle *L. olivacea*. The contribution of the present study is to continue carrying out investigations regarding the taxonomic identification of these epibionts, as well as the effect and damage that these guests cause in marine turtles. Epibionts were gathered from marine turtles during 4 seasons on the beaches of Chalacatepec, Villa del Mar and Playón de Mismaloya, Jalisco, Mexico; these organisms were collected from the soft and hard parts of the females. The most common organism was the species *Poducerus cheloniphilus*, followed by the barnacles *Lepas hilli* and *Stomatolepas praegustator*.

PHOTO-IDENTIFICATION OF JUVENILE HAWKSBILL SEA TURTLES USING FACIAL SCALES

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Using two methods, we assessed the utility of lateral facial scales for identification of juvenile hawksbill sea turtles captured and released in a feeding aggregation in the Dominican Republic. The first method consisted of presenting inexperienced participants with 77 photographs from 37 individual turtles recaptured at different times (ranging in recapture intervals from 2 months to 6 years) and asking them to match the photographs corresponding to the same individual (established in situ by the presence of Inconel tags). This was done to establish the consistency of facial scale patterns through time. Secondly, participants were asked to match recaptured individuals´ photographs to a larger catalogue containing 400 individuals organized according to common facial scale features. This was done to determine the practicality of using photographs for individual identification with a photographic reference database. Both methods proved that lateral facial scales are indeed a reliable method for photo ID of hawksbill turtles. We also determined that, unlike loggerheads, postorbital scales were not useful for individual identification. Instead, in this species, timpanic scales and those scales surrounding the postorbital scales proved to be the most useful.

RESCUE, TRIAGE AND RELEASE (RTR): A NEW APPROACH TO MANAGE THE LOGGERHEAD TURTLE (*CARETTA CARETTA*) RECOVERY

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The loggerhead sea turtle (*Caretta caretta* (Linnaeus, 1758)) is a cosmopolitan species widespread in tropical and temperate waters. It inhabits the entire Mediterranean basin although nesting sites are found exclusively in the eastern basin (Greece, Turkey, Cyprus, Libya). Since 1996, *C. caretta* was included by the Marine Turtle Specialist Group in the IUCN red list of threatened species as endangered. Therefore, the number of rescue and rehabilitation centres funded by major conservation organizations (i.e. WWF, Legambiente) has increased in the last few years. These rescue centres are involved in the recovery and rehabilitation of the animals found stranded or accidentally captured in fishing nets and longlines. The objective of the present study is to propose a scientific investigation protocol to evaluate the health state of each animal, in order to release them as soon as possible. We carried out a census of all the recovery centres operating in Italy, and examined the guidelines and regulations in force. Recovery centres generally operate by following the guidelines on first aid, assistance, rehabilitation and release of sea turtles species (AA.VV., 1999, RAC / SPA, 2004, Tunes and Go, 2007). Every year several hundred specimens are rescued by these facilities: 14 structures refer to the Tartanet-Legambiente network, 10 to the WWF Italy network for sea turtles conservation, and an imprecise number of public and private structures belonging to research institutions. The objectives of these centres are: 1. Recovery and rehabilitation. 2. Education, training and information of public. 3. Participation in network of rehabilitation centres to influence management strategies of this species, and legislative activities to improve its protection. 4. Investigations about reasons of death and diseases of the species. 5. Scientific research. 6. Dissemination of data to the scientific community. We propose an investigation protocol to be performed on specimens recovered, in order to assess the health state of individuals on an objective basis, and to release them with a reasonable expectation of post-release survival. In this way we can focus the assistance efforts on the animals with serious problems. This requirement has been already raised by some authors, but in this case we would like to propose an objective path to do health, clinical and biological inspections, based on existing literature. The protocol is based on a total of 16 parameters, separated in 4 test categories: health state, radiology, haematological examinations and microbiology (presence of bacteria, viruses and parasites). The results are expressed through a numeric score ranging between -6 and +1: if it is positive it means that the parameter monitored is within the physiological limits of the species, otherwise if it is negative. The sum of individual scores, weighted for each parameter, determines a total value that allows the classification of the specimen into two main categories: “releasable” (if the total score ranges between 10 and 16) or “temporarily not releasable” (if the total score is <10). Using this triage standard procedure it is furthermore possible to increase the predictive ability based on review of released and eventually recaptured specimens.

*PLASMA BIOCHEMISTRY VALUES OF FREE-RANGING AND CAPTIVE GREEN TURTLES IN TAIWAN

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Since the sea turtle stranding network was established in Taiwan, the numbers of reported stranded (including sick and injured) turtles increased each year. Therefore, there is an urgent need for research on plasma biochemistry of sea turtles in Taiwan. The purpose of this study is to establish plasma biochemistry reference baseline profiles for free-ranging green turtles and use them for health assessments of captive and stranded sea turtles on the regular basis. In the first part of this study, we collected blood samples from 27 by-caught, clinically healthy and 4 nesting green turtles for the establishment of the reference range. Studies found that the subadult green turtles had lower

PCV and higher AST values than the adults. Glucose, BUN and UA values were lower in the nesting green turtles than the non-nesting adult females. However, the nesting females had higher triglyceride and Mg concentrations. These differences might relate to the nesting activities of the female turtles. Second, blood samples were obtained from 24 captive green turtles and it was found that they had significantly higher albumin, AST, Mg and BUN than the normal greens. These results might relate to the daily diet and their nutritional status. We also compared the plasma biochemistry between the clinical sick turtles and clinically health captive green turtles. Results showed that the sick turtles had a higher A/G ratio which may relate to the dehydration and immune-suppression of the sick turtles. These are the first plasma biochemistry baseline profiles ever established for the free-ranging green turtles in Taiwan. We can now use it to properly diagnose the health status of captive and live stranded green sea turtles in Taiwan.

TONIC IMMOBILITY: AN ETHICAL, LOW-STRESS AND SAFE METHOD OF SEA TURTLE RESTRAINT

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Tonic immobility (TI) occurs in many vertebrate groups from sharks ("shark hypnosis"), bony fish (trout tickling and catfish noodling), frogs, lizards, skinks, iguanas, crocodiles, and birds including chickens and quail ("chicken hypnosis"). TI has been variously attributed to death feigning, fear response and stress. It has been used to immobilise sea snakes for measuring and tagging prior to release. Hatchling sea turtles are susceptible to TI especially when fresh from the nest. Applying finger pressure to the nose and stroking the neck region causes immobility. This makes measuring, weighing and marking hatchlings easy and quick. Subadult green and hawksbill turtles succumb to TI by stroking their neck. Adult green and flatback sea turtles are also susceptible to TI. This sets up safe working procedures that are practised before meeting a turtle on a nesting beach. This is especially important when dealing with companies that need Job Hazard Assessments with strict injury reporting procedures and conservation agencies that want ethical low-stress handling of wildlife. Using TI, even a small-bodied assistant can restrain an adult green sea turtle returning to the sea after nesting. TI starts with the assistant massaging the neck and throat of the turtle. The couple of minutes of immobility so gained enable a skin biopsy and carapace measurements to be collected and temporary and permanent tags to be applied. This removes the risky and dangerous practice of physically restraining a struggling adult turtle during which the turtle and researcher risk injury.

*HEALTH ASSESSMENT OF LEATHERBACK TURTLES NESTING ON BIOKO ISLAND, EQUATORIAL GUINEA, AFRICA

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Leatherback turtles are the most endangered sea turtle, yet very little information is known about the health status of this species and how it relates to the overall health of the ecosystems they inhabit. Available publications reporting hematology and biochemistry values of nesting leatherbacks are limited. In 2008, 55 blood samples were collected from 23 individual turtles nesting on Playa de Moaba, Bioko Island, Equatorial Guinea. Samples were collected from either an interdigital vein in one of the hind flippers or from the dorsal cervical sinus. All blood samples were processed in the field for plasma biochemistry and hematologic values within an hour of collection. Physical examinations and reproductive output information were recorded for each animal throughout the nesting season. Based on physical examination and reproductive output data, the general health status of this population was rated as good and hematologic values of these individuals are presented. More studies linking the health parameters of leatherbacks with nesting ecology data are necessary to establish baseline health data for this species, especially in regions such as the Gulf of Guinea where oil extraction poses a significant threat to the continued health of the population.

ALARMING RATES OF UNDERGROUND EGG PREDATION RELATED TO DORYLUS ANTS IN LEATHERBACK NESTS (PONGARA NATIONAL PARK, GABON CENTRAL AFRICA)

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The Republic of Gabon (Central Africa) hosts the largest nesting aggregation in the world for the leatherback turtle, *Dermochelys coriacea*, yet there is still a paucity of detailed knowledge of many key aspects of reproductive ecology at the site. Here we present a comprehensive study of incubation success under natural conditions in which underground predation appears to be a major cause of egg mortality. A total of 163 nests were followed to term and excavated at Kingere beach in Pongara during 3 consecutive seasons (2005/2008). Nest survival (defined as the percentage of nests that produce at least one live hatchling) was only 40% and mean hatching success of natural nests was only 16.6% (including nests with zero hatching). Of the excavated nests, 94% had at least one egg predated. Mean nest predation rates were 52% upon yolked eggs and 39% upon SAG (Shelled Albumin Globules) ranging from 0 to 100%. Contents of predated eggs ranged from plain sand with ant corpses to rotten egg remains or humus. 49% of the predation was attributed to insects (n=75 nests), and 18% to crabs (n= 28 nests). The remaining 33% of the nests (n= 51) had evidence of both type of predators. Army ants, *Dorylus spininodis,* were found in 56% of the excavated nests (n=91). This was the first record of this species in Gabon. They were sometimes seen actively infesting the nest with distinct galleries (n=4) but most frequently large numbers (hundreds of ants) were found dead within eggs (n=80 nests). Predation was also found to be a major constraint for egg relocation programs, as proven by two pilot hatchery sites where none of the nests hatched. The most productive beach sector in the study area was an ancient lagoon mouth that acted as a "predation free island". Other invertebrates such as termites, acarids and beetles were found during nest excavations and identified but none of these is likely to be an egg predator. Additional data were gathered during 2008/2009 season at Pointe Denis (n=30 nests) and Mayumba (n=27 nests) where ant presence inside leatherback nests was not found to the same degree. We suggest that this might be a particular phenomenon at Kingere and possibly other sites, where narrow beaches are bordered by dense forest. Further research is necessary to elucidate whether ants are the primary or secondary predator and whether they have specialized in exploiting turtle nests.

SEA TURTLE RESEARCH AND REHABILITATION CENTRE (DEKAMER), DALYAN, MUGLA-TURKEY

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Mediterranean populations of sea turtles are isolated from the Atlantic and they are genetically different. The estimated numbers of adult females are 2,000 for loggerhead turtles and 500 for green turtles in the Mediterranean. Both species of sea turtles are listed on the 2008 IUCN list as endangered with a declining population and are known to nest on the eastern coasts of the Mediterranean in Turkey. Though loggerhead sea turtles are known to nest along the majority of the coast, green sea turtle nesting sites tend to be limited to only a few beaches. In the Mediterranean, Turkey has the most important green turtle nesting sites and the second most important loggerhead turtle nesting sites. Every year, an estimated 1,360–2,710 *Caretta caretta* nests and 700–1,150 *Chelonia mydas* nests are found on Turkish beaches. In an effort to protect the declining numbers of turtles, it is most important to ensure the survival of as many offspring as possible. Despite having nesting and foraging grounds along the Mediterranean coast of Turkey, the only turtle rescue centre was established in 2008 following the RAC/SPA (Regional Activity Center/Special Protected Areas) guidelines. This center is to be set up for year-round activity and also helping to

educate the public about conservation efforts. The fishing industry has had a negative effect on the population of sea turtles by means of bycatch and strangulation and hook ingestion. The protection of nests on the beach and the treatment of injured turtles are vital for the survival of the very low number of Mediterranean Sea turtles. There were 14 injured turtles at the rescue center until the end of October 2009. Upon arrival to the rescue center, turtles were weighed and measured and scored by body condition. Files were also compiled for each individual turtle and updated daily with treatments and lab results. Each wound was assessed, based on depth and the extent of damage, then disinfected. Fractures or lesions were given first priority and any debris was removed. The turtles that sustained significant injuries were placed into a tank without water to avoid contamination. Antibiotics were administered if deemed necessary. Fishing hooks and foreign bodies are a common medical problem in sea turtles especially due to the presence of keratinized papillae in their esophagus and were only removed if causing an obstruction or will not cause damage to surrounding soft tissue but can pass on their own. The main problems found on these injured turtles were propeller cuts (n=5) from boats, fishing line cuts (n=3), fishing hook ingestion (n=3), speed boat crash (n=2) and a gunshot (n=1). A large effort is made to increase public awareness because its importance to the overall goal of sea turtle protection is crucial to the survival of the species. An outreach program to the local people, students, tourists and tourist companies was created by DEKAMER. The center provided information to around 30,000 visitors during the year 2009.

OXIDATIVE STRESS AND ORGANOCHLORINE PESTICIDES IN BLACK TURTLES *CHELONIA MYDAS* CAPTURED IN FORAGING COASTAL LAGOONS IN THE OCCIDENTAL COAST OF BAJA CALIFORNIA SUR, MEXICO

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The effects of chemical contaminants, such as organochlorine pesticides, in wildlife can be measured at different levels of biological organization. Coastal lagoons of the Baja California peninsula are important feeding grounds for black turtles, where individuals reside for up to 20 years. In order to determine contaminant levels and their potential effects in black turtles, individuals were captured alive in Punta Abreojos (PAO) and Bahía Magdalena (BMA) during 2005–2006. Morphometric data were recorded and a blood sample was collected from each turtle and a relative body condition index (Krel) was estimated using length and weight data. The predominant (>70%) age class captured was juveniles (<77.3 cm straight carapace length, SCL). Injured black turtles from BMA and PAO showed lower body condition, Krel, than healthy ones; injured sea turtles from PAO also showed less increase in Krel per centimeter of SCL. The higher frequency of individuals with residuals of pesticides in plasma was registered in PAO. Black turtles from BMA had higher concentrations of α-BHC, hexachlorobenzene, lindane and aldrin than PAO. Lindane was the most prevalent (in 85% of individuals) of 25 organochlorine pesticides examined. The contaminant classes detected in most of the individuals were the benzene hexachlorines (BHCs), heptachlors and the hexachlorobenzene. Injured black turtles showed higher concentrations of heptachlor in PAO and γ-Chlordane in BMA compared to healthy ones. There were no differences in the antioxidant defenses between injured and healthy black turtles of PAO. In BMA the activity of superoxide dismutase (MnSOD) was higher in healthy than injured sea turtles. Neither lipid peroxidation (TBARS) nor the activity of any antioxidant enzyme analyzed was correlated with body condition (Krel). Nevertheless, the body condition of the sea turtles decreased as the concentration of β-BHC increased, and the activity of the antioxidant defenses was correlated to the concentration of many xenobiotics as follows: the activity of superoxide dismutase (CuZnSOD) was correlated to α-BHC; glutathione peroxidase (GPX) to γ-BHC; catalase (CAT) to α-BHC, β-BHC and lindane; and glutathione transferase (GST) was correlated with the concentration of endrin, γ-chlordane, aldrin, heptachlor and hexachlorobenzene. These results suggest a physiological sensitivity to xenobiotics of black turtles. The sea turtles from both zones were susceptible to ambient perturbations, which could be influenced by currents (PAO) and agricultural activities (BMA). The results suggest that for black turtles GST is a good biomarker of exposure to contaminants considering it detoxifying function. Because that the severity of the effects and potentially toxic concentrations of the contaminants for black turtles are unknown, the results should be taken as baseline for more systematic studies.

*THE RESPONSE OF POST-DIVE RESPIRATORY BEHAVIOR TO THE DIVE ACTIVITY OF SEA TURTLES

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For air-breathing marine vertebrates, oxygen consumption during dives is an important factor to limit their dive duration. It is known that number of breaths at the sea surface has a positive relationship with the previous dive duration for sea turtles (Lutcavage and Lutz, 1991). However, the relationship between post-dive respiratory behavior and diving activity has not been revealed yet. A recent study developed a monitoring technique for respiratory behavior of sea turtles by detecting head pitch of turtles using an acceleration data logger (Okuyama *et al*. 2009). In the present study, we conducted field experiments using the acceleration data loggers to reveal the relationship between the post-dive respiratory behavior and the diving activity of sea turtles in the wild. We used three subadult green turtles (A: 49.2, B: 60.9, C: 55.3 cm SCL) captured around Aragusuku Island, Okinawa, Japan. We attached the acceleration data logger (M190-D2GT, Little Leonard Ltd.) to the head and the speed/acceleration/depth data logger (W1000L-3MPD3GT, Little Leonard Ltd.) and time-scheduled release system to the carapace. Turtles were released near the area where they had been captured. At a scheduled time (A: 3 hours, B: 120 hours, C: 72 hours), data loggers were automatically detached from the turtles, and then popped up to the sea surface. As a result of this study, we were able to retrieve the data loggers from two turtles (Turtle A and B). We obtained 55 and 172 sets of dive and respiratory data from Turtle A and B, respectively. In the results of this study, the post-dive breathing duration was closely related to the number of post-dive breaths. In addition, the number of post-dive breaths and the post-dive breathing duration linearly increased with the increment of dive duration, and exponentially increased with dive activity. Linear mixed model analysis indicates that dive duration has more effect on post-dive respiratory behavior than dive activity, which indicates that basic metabolism is a stronger limiting factor of respiratory performance than activity metabolism.

VALIDATION OF GONAD AND REPRODUCTIVE DUCT MORPHOLOGICAL CHARACTERISTICS FOR SEXING HAWKSBILL SEA TURTLE HATCHLINGS

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Sex identification in hatchling sea turtles is difficult since they lack external sex-specific characteristics. Recent research has proposed a reliable sex determination method for green (*Chelonia mydas*) and loggerhead turtle (*Caretta caretta*) hatchlings based on 6 morphological characteristics of the gonads and reproductive ducts (paramesonephric duct size, mobility of the duct, gonad mobility, gonad shape, edge form, and presence of complete lumen). In the present work, we tested the applicability of these characteristics for an additional cheloniid species: the hawksbill sea turtle (*Eretmochelys imbricata*). Our sample consisted of hatchlings found dead in the nest after hatching, preserved in formalin or fresh. All nests were obtained from Saona Island (del Este National Park, Dominican Republic, 18°07'N 68°44'W). A total of 31 hatchlings from 11 nests were analyzed. Definite sex determination was performed using gonad histology, and results were compared with incubation temperatures and period. Four of the 6 characteristics evaluated (mobility of the duct, gonad mobility, gonad shape, and edge form), proved to be useful for reliably predicting sex in hatchlings of hawksbill turtles. Work is in progress to validate a fifth characteristic: the paramesonephric duct size. Although this is a preliminary work, the development of such technique of direct sex assessment will provide huge benefit for adequate management of conservation projects on this seriously threatened species.

EXPRESSION OF SOX9 AND HOX GENES IN THE EMBRYONIC REPRODUCTIVE TRACT OF *LEPIDOCHELYS OLIVACEA* DURING SEX DETERMINATION

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Sex determination in vertebrates, the process of commitment of the gonad to become ovary or testis from a bipotential gonad, can be initiated by genetic or environmental factors. When the temperature is the critical factor for sex determination, this process is known as temperature-dependent sex determination (TSD). Despite different mechanisms of sex determination, the morphogenesis of the gonads is conserved between mammals, birds and reptiles, suggesting that sex-determining pathways share genes in common. In mammals, sex determination depends on the Sry gene; however, no Sry homologue has been found in birds and reptiles; nevertheless, homologues of several other mammalian sexual genes have been identified. Among them, the autosomal Sry-related gene, Sox9, has been implicated in testis differentiation in mammals, birds and reptiles. Hox genes could also be involved in sex determination because of their crucial role during embryogenesis; these genes are evolutionarily conserved and necessary for body axis patterning. Hox genes have never been studied in organisms displaying TSD. In the present work we examined the expression of Sox9, HoxD11 and HoxA13 in gonads of *Lepidochelys olivacea* embryos incubated at male-promoting temperature (MPT-26°C) and female-promoting temperature (FPT-33°C) by qPCR and in situ hybridization. We obtained the complete coding sequence of *L. olivacea* Sox9 gene (GenBank Accession No. GQ258676), and partial sequences of *L. olivacea* HoxD11 (GQ258677) and HoxA13 (GQ258681). We observed a quantitative and spatial differential expression pattern of Sox9; suggesting that up-regulation of Sox9 together with a change in the expression site at the onset of testicular differentiation, play an important role in testis development; whereas down-regulation and also a change in the expression site could be involved in female sex differentiation. Besides we found a differential expression pattern in genital ducts, where Sox9 is expressed in both Wollfian and Müllerian ducts in males but not in females during sex differentiation. On the other hand, Hox gene expression patterns suggest that HoxD11 and HoxA13 could play a role in the female pathway rather than the male pathway, since a down-regulation of both genes could be necessary for ovary differentiation. Furthermore, we found a differential expression pattern of HoxA13 in the genital ducts, in which HoxA13 was expressed at MPT but not at FPT, suggesting a role in the maintenance of the Wolffian duct and in the morphological and functional restructuring of the Müllerian duct in males.

ASSESSING BARNACLE RECRUITMENT AND GROWTH COINCIDENT WITH DEBILITATED TURTLE SYNDROME

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Data from the South Carolina Department of Natural Resources for 2000–2009 indicate that 10% of the loggerhead (*Caretta caretta*) strandings in South Carolina, USA, exhibit symptoms of Debilitated Turtle Syndrome (DTS). Loggerheads with DTS are characteristically emaciated, hypoglycemic, anemic, and heavily encrusted in barnacles. Health assessment and necropsy data indicate that sea turtles are being affected by a wide range of secondary bacterial infections and parasites with the primary causes still unknown. Presumably, the illness ultimately weakens the turtle to the point that it floats at the water's surface, restricting the animal to an environment that predisposes it to heavy barnacle recruitment. This allows for especially heavy loads of the barnacle *Chelonibia testudinaria* to accumulate on the carapace and soft tissue. The time it takes for debilitated loggerheads to manifest this heavy barnacle load is unknown. Our study experimentally tested whether barnacle recruitment on loggerhead carapaces varies between debilitated and non-debilitated individuals and measured how barnacle growth rate correlates with several environmental factors. Findings from this study will be used to develop a protocol that allows scientists and veterinarians to use barnacles as a biomarker for estimating the length of time that a debilitated loggerhead has been

passively floating. Floating arrays holding barnacle settlement panels consisting of debilitated turtle carapace, non-debilitated turtle carapace, Plexiglas, and slate tile were placed at four independent experimental sites (one offshore and three inshore sites) near Charleston, South Carolina, USA. The arrays were monitored weekly for barnacle recruitment and growth. Data loggers were attached to each array to record hourly temperature data and salinity and phytoplankton measurements were monitored weekly. Variability in recruitment and growth rates among the four experimental sites was determined using Analysis of Variance (ANOVA). A trajectory for barnacle growth at each site is also being developed. Preliminary results from season one data (2009) suggest that there are significant differences in general barnacle recruitment among sites. Recruitment rates were highest at the offshore location. Across sites the patterns of treatment panel preference were inconsistent among all barnacle species; however, recruitment rates for *C. testudinaria* are still under analysis. Additional temperature, salinity, and phytoplankton data from season two (2010) is necessary before their effects on barnacle recruitment and growth can be determined. A larger sample size is needed to complete growth curves and to determine if growth rates differ among locations. Similar field sites and methodologies will be used in 2010 with minor modifications to the original design for improved sampling. Establishing growth rates will ultimately enable natural resource managers to estimate the onset and duration of DTS affecting stranded loggerheads.

ABOUT UNUSUAL DEBILITATED LITTLE LOGGERHEAD TURTLES BEACHED ON THE NORTHWESTERN ADRIATIC COASTS

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The summer of 2009 and particularly between the end of July and the end of August were very interesting because of the high number of little loggerhead turtles beached on the Adriatic Italian coasts. In fact, from the 31st of July and the 24th of August, the northwestern Adriatic coasts saw a lot of loggerheads stranded alive. All the thirteen animals, also found in the Provence of Ferrara (north western Adriatic Sea), were tiny with a CCL between 17 and 23 cm, debilitated, dehydrated and anaemic, and totally covered by different species of barnacles, such as to hamper every single movement, particularly swimming. In fact, all the animals were shown to have been eating only plants because of the amount of *Zostera* sp. found in faeces for several days after the recovery. Most of those animals were hospitalized for about one month, receiving antibiotic treatment and appropriate food. Two of them, particularly thin and anaemic, died four and thirty nine days respectively after the hospitalisation, with a very low biochemistry result of albumin (0.1); ten turtles were released and only one is still too emaciated to be released. The most frequent and common bacteria found were *Pseudomonas* and *Aeromonas* and only two individuals were affected by an interesting variety of *Vibrio*. Although the cause of debilitation is still unknown, we put forward some hypotheses, correlating with environmental parameters of the area. Genetic analyses of *Caretta caretta* in the Adriatic Sea showed no genetic differentiation both at a nuclear and mitochondrial level within the Adriatic Sea. At the mitochondrial level, Adriatic samples were compared to published Atlantic haplotypes and they showed significant differentiation. Investigation outcomes are shown herewith and refer to blood samples, barnacles, and clinical, virological, toxicological, genetic and biological investigations pertaining to the specimens discovered along these shores.

REVOLUTIONARY SWIMMING DEVICE TO ASSIST A TRIPELIGIC SEA TURTLE; A SUCCESSFUL TRIAL

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Sea turtle rehabilitation most often focuses on rehabilitating the animal for return to the wild. Occasionally, a non-releasable turtle becomes a captive animal in a public facility to foster public endorsement through education. Surviving animals not suitable for either of the above purposes are euthanized. But a revolutionary swimming device fitted on a one flipper of an Atlantic Green sea turtle not only provided the animal with the ability to survive in a deep captive environment, it created a huge wave of media attention and, thus, public awareness and endorsement for endangered sea turtles. Featured on The Today Show, Discovery Channel, MSNBC, People Magazine and most major newspaper publications in the US, Mexico, Canada, Australia, Asia, and Latin America, the turtle named "Allison" has become a public relations ambassador for all sea turtles. Developed by a 21 year old intern at Sea Turtle, Inc, a nonprofit rescue center for injured sea turtles in South Texas, this device creates drag utilizing a "dorsal" type fin attached to a wet suit. This drag counters the turtle's spinning motion and pushes her forward. Presented are the trials, failed prosthetic attempts on a rear stump, and ultimate success of this "dorsal" type device. A video presentation is available. Sea Turtle, Inc. was founded in 1977 with the following mission: rehabilitate injured sea turtles for return to the wild, educate the public about sea turtles and their marine environment, and assist with conservation efforts for all marine turtle species. The center has successfully rehabilitated and returned to the wild over 200 turtles since 2001. Funded solely by public donations, the center is open to the public year round and routinely treats injured greens, hawksbills, loggerheads, and Kemp's ridleys.

*INFLUENCE OF SMALL VESSEL PROPULSION SYSTEM AND OPERATION ON LOGGERHEAD SEA TURTLE INJURIES

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Injuries to loggerhead sea turtles are frequently attributed to impacts from small motorized vessels such as are commonly operated in coastal waters of the United States and elsewhere. It is often difficult to determine what type of vessel caused the injuries, under what conditions, or if the animal was dead or injured prior to the final impact. But the answers to these questions have potential resource management implications, providing the motivation for the study described here. A series of tests is described that were designed to investigate the types of injuries inflicted on model loggerhead sea turtles by small vessels (a 5.5 m flat-bottomed skiff and a 3 m jet-drive vessel). In one series of tests, the skiff was powered by a traditional outboard motor and propeller, with and without commercially available propeller guards designed to reduce the likelihood of injury (primarily to humans in the water). Another test series featured the same vessel with a jet outboard propulsion unit. A major component of the project was the development of a full-scale model loggerhead turtle, with appropriate size, weight, and carapace strength. Coupons were harvested from deceased animals and tested for material properties. This required the development of new material testing techniques adapted from approaches used for testing of human bone. A fiberglass composite material was then selected to provide a similar tensile strength per unit width, compared to the natural material, and the composite material was used to form model turtle carapaces via a hand lay-up process. Fabricated models were also tested in the laboratory to assure correct tensile properties. A frame and a buoyancy unit were designed, to simulate the torso of the animal. The carapace was attached to the frame and deployed in the water for testing. Tests were conducted at three different speeds, representing idle, sub-planing, and planing conditions, and at two elevations in the water column (on the water surface, and submerged to the depth of the boat propeller). The models were struck 1) by the standard outboard motor with and without prop guards, 2) by the outboard jet drive and 3) with the jet ski. Test results reveal that the types of injuries seen in deceased animals can be replicated through the testing process described above. For the skiff with the standard outboard motor, propeller and/or skeg damage occurred even at low speed, with the magnitude of the damage typically greater for higher speeds or when the animal was at

the surface. The tested prop guards reduced damage attributable to the rotating propeller at idle speed, but the larger projected area of the motor foot with the prop guards installed resulted in significant impact damage to the model carapace at higher speeds. Trials conducted with the jet outboard and jet ski did not produce significant damage to the carapace or frame at any speed or depth.

EXTERNAL INJURIES AND THEIR DISTRIBUTIONS IN WILD LOGGERHEAD TURTLES

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External injuries of wild loggerhead turtles were examined for individuals incidentally captured in pound nets operated in the Sikoku of Japan. From July 1, 2009 to August 12, 2009, we observed injuries on the body surfaces. The average Straight Carapace Length (SCL) was 768±59.7 mm, and weight was 82.8±8.5 kg. We categorized external injuries into four types, that is, cut, scratch, bite, and hollowed injury types, and recorded their region, length, and depth. The depth of injury was categorized in 4 levels as stage I, II, III, IV, after that, we got each stage into 1 to 4 variable. Additionally, we set up an expression "length(cm)×depth(1–4)" that generated the score for the degree of injury, expressed as Injury Score (IJS). The highest total IJS score was 183.1, and there were 4 turtles that scored the lowest mark, 0. When we understood the distribution of histogram, we figured out that the 0–20 injury class was the most common group of turtles, and the higher the class, the fewer the number of turtles. Bite was the most common form of injury, secondly cut and next was scratch. From the condition of injury, we would estimate if the bite or cut was caused by a shark. The marginal region had the highest IJS score of the carapace, plastron marginal region, and limbs. In a little detail, in marginal region, the 8th left marginal represented the highest IJS score, next the 7th left marginal, and then the 5th right marginal. Front limbs were higher scoring than hind limbs. In addition, pleural in the carapace and plastral scales in the plastron indicated a higher score. Furthermore, SCL was not correlated with IJS, but SCL was positively correlated with IJS ($n=34$ $r=0.604$ $p=0.0489$) when lower scores of IJS (under 50) were removed, and from this we would suggest some turtles accumulated external injuries on the body surface as they grew while others were resistant to injury.

MIGRATION & NAVIGATION

HIGH PLASTICITY OF LOGGERHEADS ON NESTING SITE FIDELITY: FROM USING REPEATEDLY THE SAME SMALL BEACH DURING DIFFERENT SEASONS TO DEPOSITING CONSECUTIVE NESTS IN DIFFERENT ISLANDS DISTANT MORE THAN 100 KM

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Sea turtles exhibit a strong natal homing associated with a high nesting site philopatry. Mark-recapture and genetic studies confirm these patterns suggesting differences among and within species. In the present study, we have analysed the degree of nest site fidelity of a loggerhead population nesting on the islands of Cape Verde and have evaluated the existence of intrapopulational variability in this trait. The loggerhead is the only sea turtle species that nests in Cape Verde, and 15,000–25,000 nests per season have been estimated for the whole archipelago. Around 90% of nests are deposited in the island of Boavista, and 9% of nests are equally distributed among the islands of Sal, Maio and San Nicolau. During the past 12 years more than 10,000 loggerhead adult females have been tagged and recaptured on different islands but the future of the rookery is considered uncertain, especially because of the consumption of turtle meat. We have found gravid females moving among islands. For example, in 2009 a female nested in July in Santiago and in August in Boavista. Both islands are separated by at least 130 km. A similar behaviour was found by several females between Boavista and Sal, two islands separated by at least 50 km. The distances among islands were not very large but females had to leave the platform shelf, crossing very deep waters (>1,000 m) with strong currents. Within Boavista, we have also found that the 30% of females have nested in beaches separated by more than 20 km from the beach where they were marked. But at the same time, many females have repeatedly nested in the same small beach (shorter than 2 km) even in different nesting seasons. For example, a female called Hortensia buried 5 nests within 400 m during 2004 and returned to nest to the same beach stretch during 2006. This high plasticity in nesting site fidelity has important implications for the design of conservation strategies. Protecting selected high density beaches is not enough to save all individuals that nest on those beaches. Nesting dispersal has occurred among islands that are up to 130 km away. Consequently, we believe that in Cape Verde, all islands could be connected for loggerhead nesting. The lack of genetic structure among islands confirms this pattern. The rate at which this long distance dispersal happens should be studied in order to evaluate whether natural nesting dispersal is enough to facilitate recolonisation of islands where loggerhead nesting has been extirpated in the past decades. However, whether the Cape Verdean loggerhead rookery can contribute to the recolonisation of the African continent, more than 500 km away from the archipelago, remains unknown. Highly populated islands with a severe reduction of nesting activity and a strong harvesting pressure on loggerheads could be sinks for the whole population. Increased understanding of the degree of nest site fidelity and connectivity among islands is very important to design and establish the priorities for loggerhead conservation in Cape Verde.

HOME RANGE AND MIGRATION OF EAST PACIFIC GREEN TURTLES TAGGED IN COCOS ISLAND NATIONAL PARK, COSTA RICA

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Cocos Island National Park was established in 1978. Located 532 km southeast of Puntarenas, this oceanic island has a land surface of 24 square km and enjoys a 22.2 km radius of protected waters. Four species of sea turtles have been recorded in Cocos Island: East Pacific green turtles are the most common, although hawksbills, leatherbacks and olive ridleys are also seen. As they leave their most important rookery in the East Pacific, located on Costa Rica's mainland, a large portion of the post-nesting open ocean migration route of critically endangered Pacific leatherback turtles has already been shown to include the territorial waters (EEZ) of Costa Rica and Ecuador that surround Cocos Island and the Galapagos Islands. The largest remaining nesting rookery for Pacific green turtles is at the Galapagos Islands, with fewer numbers nesting in Central America and Mexico. Furthermore, an important feeding and developmental site for this species has been identified in Gorgona Island, Colombia. It is currently not known where adult or juvenile green turtles found at Cocos Island National Park originate. If these turtles utilize either the Galapagos, or the coast of Costa Rica for reproduction, they may share migration routes with East Pacific leatherbacks. If they utilize Gorgona during juvenile development stages, it is necessary to establish the existence of connectivity and migratory patterns. A sea turtle monitoring program was initiated in Cocos Island in March of 2009. So far, two East Pacific green turtles have been satellite tracked using Spot 5 Tags, and three green turtles and one hawksbill were tagged using Sirtrack tags. A total of 28 sea turtles have been caught by hand while scuba diving (27 Pacific green turtles and 1 hawksbill), all of which were tagged externally with metal flipper tags. Eight green turtles and one hawksbill were also outfitted with acoustic tags. A photographic record of all sea turtles is being kept of the right profile of the face for photo ID. Tissue samples are taken from all individuals for later genetic analysis. So far, the data collected show that a significant population of juvenile and adult green turtles, as well as juvenile hawksbill turtles, use the habitats along the northern rim of the island to forage, and possibly as a developmental area for juveniles as well, where individuals may stay for years until they take up a pelagic existence. Home range analysis shows an area of high intensity use between Manuelit and Dirty Rock. Only one turtle headed to the northern coast of Panama migrating along the Cocos Ridge, which has also been described as the migratory corridor for leatherbacks. Three more expeditions are planned for 2010, during which at least nine more green turtles will be tagged. The knowledge generated is expected to assist the establishment of management measures, such as increasing the marine protected area around Cocos Island National Park, and creating corridors between Costa Rica, Ecuador, and Colombia where sea turtles are protected from fisheries during times of high interaction.

MODELING SPATIAL POPULATION DYNAMICS OF ADULT AND IMMATURE GREEN TURTLE (*CHELONIA MYDAS*) IN THE SOUTH-WEST INDIAN OCEAN

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More than twenty years of active research on green turtles (*Chelonia mydas*) in the South West Indian Ocean (SWIO) have contributed to improve knowledge of the biology and ecology of the species. However, gaps still remain regarding interactions between the main behavioral processes: development, reproduction and migration, while shifts in these processes at the individual scale have major impacts at the population scale. On this basis, we have started implementing a spatially explicit individual based model (IBM) to assess population dynamics of the

green turtle in the SWIO. Our simulation experiment aims to unify in a single model growth, navigation and reproduction constraints as well as potential changes in foraging or breeding sites. At the present time, we found no spatially explicit IBMs implemented focusing on green turtles. According to the complexity and relative uniqueness of the biological cycle of *Chelonia mydas*, individual-based modeling appears to be the most suitable method to assess (1) how important is the role played by development, reproduction and migration in green turtle population dynamics, (2) how these three behavioral processes interact and constrain each other and (3) how sensitive they are regarding environment variability. Active research programs in the SWIO have generated and are still generating a large number of data focused on green turtles that are integrated into the model: (1) recent nesting population status and seasonality based on long-term beach monitoring started in 1985, (2) nest parameters and activity based on yearly nest monitoring and measures of incubation temperature since 2006, (3) regional genetics known for the SWIO, (4) physiological studies conducted on captive and on free-living individuals since 2007 and (5) bycatch and fishing effort estimate through IOTC (Indian Ocean Tuna Commission). Moreover, to identify migrations routes and characterize immature open sea behavior, at least 140 satellite transmitters will be attached mainly on female and immature green turtle individuals during development, nesting and non-nesting phases. Along with these biological data, oceanographic data such as currents or sea surface temperature can be retrieved from physical models as well as regional fisheries data from RFMOs. This entire set of collected data act as the basis for realistic parameterization of the model. Main results of our simulation experiment should lead to a fine evaluation of the viability of the green turtle population in the region and also to a complete description of the underlying processes. A clear view of the link between these processes could help conservation managers to identify key levels for conservation priorities: habitats conservation and restoration, fishing bycatch, pollution, poaching and so forth. The poster provides details about the data available and describes the methods used for their integration into the model. It also offers a basic view of the individual-based model design concept.

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*SATELLITE TRACKING OF LOGGERHEAD, OLIVE RIDLEY, AND GREEN TURTLES IN THE SOUTH CHINA SEA: ARE MOVEMENT PATTERNS AND DIVING BEHAVIORS OF CAPTIVE TURTLES DIFFERENT FROM THEIR WILD COUNTERPARTS?

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Satellite telemetry has been increasingly used to study large-scale oceanic movements, migratory patterns, diving activities and foraging behaviors of sea turtles globally. The experimental turtles in tracking studies are mostly post-nesting females or individuals captured from a population and subsequently tagged for deployment at the capture location or at a different location. In this first satellite tracking study of turtles in the South China Sea, we attached two types of transmitters, the ST20 and ST24 (Telonics), singly or as doubles (paired transmitters) to 12 adult sea turtles which had been in captivity for 6 to 12 years. In all, 18 transmitters were deployed on two olive ridley, two loggerhead, and eight green turtles. The aim of our study was to characterize at-sea movement patterns, travel trajectories, diving activities, and navigational capabilities and to assess whether these behavioral traits are different from non-captive wild turtles. Tagged turtles were transported 670 km away from where they were held in captivity in Singapore and released in South China Sea. Transmissions derived from PTTs en route to the release site provided an assessment of Argos Location Class accuracy when analysed with shiplog GPS data. Patterns of movements in travel trajectories, total distances traveled, and average speed of travel, bore characteristics similar to wild turtles and were influenced by factors such as geostrophic currents and proximity to islands or landmass. Deployment of paired transmitters yielded information on the fate of some of the tags: 9 of 18 lost transmissions when the turtle was within 5 km from shore. Several dive types were evident from dive parameters in the last dive. Individual and species differences in diel pattern in the mean number of dives and maximum dive duration were observed. At sea movement patterns and diving behavior from this satellite tracking study suggest that captive

turtles have an innate ability to disperse and travel like their wild counterparts when they are released into the wild. Acknowledgments: captive turtles for the study were donated by Underwater World Singapore Pte Ltd and the Port of Nagoya Aquarium. The ship MV Kota Hadiah of Pacific International Lines transported the tagged turtles to the South China Sea for release. The research was conducted with the approval of the university IACUC ethics committee and supported by the University Academic Research Grant RP 05/06 to the first author. The Satellite Tracking and Analysis Tool (STAT) at SEATURTLE.ORG was used in this study.

*RE-NESTING MOVEMENTS AND POST-NESTING MIGRATIONS OF GREEN TURTLES TAGGED IN TWO TURTLE ROOKERIES IN SRI LANKA

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Adult green turtles frequently travel long distances between feeding and nesting areas. Tagging and satellite telemetry of nesting females has provided insights into distribution and movements. We used conventional flipper tags to track re-nesting movements and post-nesting migrations of green turtles nesting in the Rekawa and Kosgoda rookeries in Sri Lanka. Tagging was initiated in September 1996 at Rekawa and in September 2003 at Kosgoda. Initially, plastic flexi tags (Dalton®) were used to tag the rear flipper of the turtles and from 1999 titanium tags (Stockbrands Co (Pvt.) Ltd., Western Australia) were used on the front flipper with an identification number and address. Tagged individuals were subsequently monitored during their re-nesting movements and post-nesting migration. A total of 1,506 green turtles were tagged at both sites with 987 from Rekawa (September 1996 to November 2006) and 519 from Kosgoda (September 2003 to July 2008). Re-nesting frequency was 78.9% at Rekawa and 54.3% at Kosgoda. Many females were found re-nesting on these two beaches and some on other beaches that were in close proximity to the original tagging sites. Of the tagged females, 55 (11%) were found re-migrating to nest at Kosgoda. Migratory patterns were determined for two female green turtles which were tracked away from the coastal waters of Sri Lanka. The first female (SL 3187) was tagged on 21 June 2005 at Rekawa and was found dead at the northern tip of the Agatti Island, Lakshadweep, India, on 31 July 2009 (four years after initial tagging). The second female (LK 0711) was tagged on 16 May 2008 at Kosgoda and was found dead on the beach in Phang-nga Province (north of Phuket), Thailand on 14 July 2009. The two individuals showed marked differences in their post-nesting migration patterns: the individual that was tagged at Rekawa migrated north to Indian coastal waters whereas the individual tagged at Kosgoda traveled northeast to coastal waters of Thailand. Both of these females were one time nesters; there are no records of them returning to the Rekawa or Kosgoda rookeries for re-nesting. Even though tag recoveries of re-migrating females have been made along the southern and western coast of Sri Lanka at Hambantota and Negombo, this is the first time that tag recoveries have been reported from outside the island, and with a travel distance of more than 2,000 km this is the longest green turtle track ever reported from Sri Lanka. Results provide evidence that Sri Lankan green turtles migrate outside the coastal waters of Sri Lanka and highlight the importance of incorporating regional coordination as recommended in the Marine Turtle Action Plan of Sri Lanka. Acknowledgements: the authors would like to thank Kajana and her colleague from Thailand and A. Koyssan, C.N. Abdul Raheem and B.C. Choudhary from India for valuable information about tag recoveries. This project is funded by the National Science Foundation and GEF/SGP of Sri Lanka. We also thank the symposium organizers for a travel grant.

EVALUATING THE PERFORMANCES OF ARGOS-LINKED GPS LOGGERS TO TRACK TURTLES OPEN-SEA MOVEMENTS

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In past years, satellite telemetry via the Argos System has provided a wealth of useful data on sea turtle migrations and movements. The system relies on radio-transmitters (Platform Transmitter terminals, PTTs) programmed to send signals to polar-orbiting satellites at periodic intervals. Recently, Global Positioning System (GPS) data loggers have been linked to Argos PTTs, so that the locations obtained through the GPS can be relayed to the Argos satellites, with no need to recover the tag. When the turtle surfaces to breathe, a percentage of GPS snapshots are transmitted via the Argos system so that the users can remotely obtain GPS-quality locations while still receiving the usual Argos-determined locations. In addition, GPS loggers store the recorded data in an on-board memory so that their recovery would allow the full archive of all GPS sampled data to be obtained as well. In the present study we analysed the location data obtained from the deployment of 12 Wildlife Computers Mk10-AF GPS tags on green turtles nesting at Glorieuses Island, a small oceanic island approximately 200 km north-east of Madagascar. These turtles were then experimentally translocated to far-away oceanic sites, and their homing trip back to the nesting island was followed for 12–26 days. The recovery of three of these tags when the turtles returned to nest at the island allowed us to download all the GPS data stored in the loggers, offering a unique opportunity to evaluate the overall performances of GPS-PTTs tags. The number of stored GPS locations could then be compared with the number of locations that the unit was programmed to obtain and with the number of GPS locations relayed to the Argos satellites. The tags were programmed to get a GPS signal every 15 minutes, for a maximum of 96 locations per day, but the three loggers were able to get only 43% of the expected locations, probably because the turtle did not spend enough time at the surface. Also, only about 51% of the GPS locations were successfully relayed to the Argos satellites. This loss of about 49% of data was likely due to a combination of the turtles being submerged for a long time (so having a short time to transmit collected data) and of the failure of Argos satellites to receive PTT signals because of their poor coverage in tropical zones. In spite of this, a good number of GPS locations were received (32 per day on average) which allowed the reconstruction of the turtles homing routes with good accuracy. Comparing the two sets of satellite-relayed location data (GPS and Argos) in all the 12 units, we found that the GPS locations were on average 47% more abundant than the Argos ones. This analysis will be extended by comparing the main features of the homing routes reconstructed by GPS and Argos locations.

*WHERE THE HAWKSBILLS REALLY ARE: SATELLITE TELEMETRY REVEALS A NEW LIFE-HISTORY PARADIGM IN THE EASTERN PACIFIC

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Life-history paradigms for sea turtles and wildlife in general rely on the definition and establishment of particular parameters and behaviors. Unfortunately, these associations often omit important and even fundamental aspects of a species' biology. In the case of hawksbill sea turtles (*Eretmochelys imbricata*), while juveniles use a variety of habitats (i.e. oceanic, rocky substrate, estuarine) for feeding and development, adults have long been considered almost exclusively coral reef dwellers. Until recently, hawksbills had been essentially written off in the eastern

Pacific Ocean due to scant reports of their presence and because there are relatively few coral reefs in the region. Beginning in 2007, several significant foraging and nesting sites were identified in the eastern Pacific, with the bulk of nesting occurring along the banks of mangrove estuaries, a behavior largely unique to the eastern Pacific, having only been documented once outside the region. The new discoveries have changed the conservation outlook for this imperiled population and opened new avenues for research and conservation. A region-wide, multi-year, exhaustive satellite telemetry effort beginning in 2008 has enabled 17 hawksbills to be equipped with satellite tags in Mexico, El Salvador, Nicaragua and Ecuador. Post-nesting females have been tracked to mangrove estuaries, habitats contrasting starkly with the conventional coral reef foraging areas used by adults in other parts of the world, where they establish restricted foraging home-ranges. Representing another newly discovered life-history trait, several post-nesting hawksbills have also been entirely non-migratory, remaining in local habitats after nesting. When migrations are undertaken, they are extremely short (range = min: 33 km, max: 305 km) and strictly neritic. Our findings suggest that long-held beliefs about hawksbills have overlooked some key characteristics. The consistent use of mangrove habitats for foraging (and nesting) and non-migratory behaviors represent a new life-history paradigm for the species and likely explain why hawksbills went virtually undetected in the eastern Pacific for decades. Furthermore, our findings highlight the value of maintaining flexible characterizations of life-history theories for hawksbills, sea turtles and wildlife in general. From a conservation standpoint, our results underscore the vital importance of conserving mangrove estuarine habitats in the eastern Pacific. Migratory routes and home ranges suggest a potential for strong physical overlap with coastal artisanal fisheries where bycatch may be an issue of concern. Considering the new life-history paradigm and the critical state of the population, there is an urgent need to conduct further research to uncover biological information that may be directly applicable to conservation and recovery efforts.

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*THE IMPACT OF OCEANIC VARIABILITY ON THE FATE OF JUVENILE LEATHERBACKS

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The fate of pelagic juvenile leatherbacks after leaving nesting beaches still is one of the great mysteries of sea turtle biology. Still, it is suspected that like in most other species, small juvenile leatherbacks spend several years drifting almost passively within the main oceanic gyres until they are seen again as much larger juveniles recruiting seasonally to coastal feeding habitats. This concept of juveniles "looping inside gyres" works well for the numerous sea turtle populations nesting on beaches bordering the main oceanic subtropical gyres, as the (almost) perfectly closed circulation of these gyres naturally maintains the juveniles in the one ocean basin bordering their natal beach. Juveniles will thus progressively "discover" this basin while repeatedly looping in it. They will later exploit this same basin as adults, likely using the navigational knowledge gained while drifting to navigate back and forth between their foraging and breeding habitats. But a number of sea turtle populations nest in areas where the offshore current pattern is highly variable in time and more complex than a single large-scale gyre. In such a situation, hatchlings can be pushed in different directions by the currents depending on the date of emergence from the nest. As a result hatchlings from the same beach can reach totally different oceanic areas and thereby experience very different life histories, a situation that has been little or not studied so far. We investigated such a case as we simulated the drift patterns and life conditions encountered at sea by hatchling and then juvenile leatherbacks originating from two New Guinea nesting beaches: Jamursba-Medi on the Bird's Head Peninsula (Indonesia) and Kamiali in the Huon Gulf on the North coast of Papua New Guinea. Using ocean currents provided by a state-of-the-art high-resolution operational ocean model (over the period January 2002 to December 2008), we demonstrated that (a) hatchlings leaving these two beaches can, within one year, drift into four different ocean basins: the North and South Pacific Ocean, the Indonesian seas and the Indian Ocean; (b) The number of hatchlings dispersing into each of these four basins displayed large interannual variations, some dispersal schemes being virtually nonexistent during some years. Using both model and remote sensing data we also estimated the water temperature and primary production (used as a proxy for forage) along all simulated hatchling tracks. This information was used to characterize the conditions encountered at sea by these hatchlings. A first analysis of the likely impact of these conditions on the survival rates in the four visited ocean basins is presented.

GOING WITH THE FLOW: LOGGERHEAD MIGRATIONS ACROSS CURRENT FEATURES IN THE GULF OF MEXICO

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The use of remotely sensed oceanographic data can better delineate the effects of ocean currents on sea turtle migrations and navigation behaviours. This is particularly true in highly dynamic environments, such as the Gulf of Mexico (GOM), which is characterised by two major oceanographic features: the Florida Current and the Loop Current (and associated eddies). The present study examined the post-nesting migrations of 28 loggerhead sea turtles (*Caretta caretta*) satellite-tracked from Sarasota County (Florida, USA), a regionally significant rookery in the GOM. Five migration patterns were observed, defined by their final destination: (i) the vicinity of the nesting beach, (ii) the south part of the Western Florida Shelf, (iii) the northeast GOM, (iv) the south GOM (Yucatán Shelf and Campeche Bay, Mexico, and Cuba) and (v) the Bahamas. We undertook a novel approach to further analyze post-nesting migration data by using ocean current data in estimating the motor path of a turtle from its recorded track (i.e. its true locomotion movements) and compared the orientation efficiencies calculated at the track and motor levels. Applied on the oceanic journeys of the long-distance migrants crossing the Florida Current or the Loop Current, this approach suggests that the turtles were deflected from their intended route but that most of them reached their expected foraging destinations. Critical cases where ocean currents may modify foraging destinations of migrating loggerheads are discussed.

*PREDICTING HATCHLING DISPERSAL USING A 3D MULTI-SCALE CURRENT MODEL

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The circulation of water around islands and reefs is a key factor in both ecological factors such as connectivity, dispersal and species assemblages and water quality factors such as sediment transport. Over the last decade advances in computing power have greatly enhanced the development of 2D and 3D models to predict the circulation of coastal waters, especially in regard to island systems. The strength of these models is that they are developed using unstructured grids and thus give rise to the development of multi scale models of hydrodynamics allowing fine scale modelling over complex systems at a variety of scales. 3D model development has also greatly enhanced quantitative and predictive studies on aspects such as the dispersal of larval and neonate fauna from coastal islands and reefs, and studies of reef connectivity. Such studies are valuable because coastal environments such as the Great Barrier Reef in Queensland Australia are threatened with a variety of impacts, and hydrodynamic models can be powerful predictive tools to better understand the implications of threatening processes and/or management practices. Consequently the 3D Second-generation Louvain-la-Neuve Ice-ocean Model (SLIM) was adapted to model circulation at a small scale adjacent to an island/reef system in the central region of the Great Barrier Reef. Given the SLIM's ability to accurately map hydrodynamic dispersal at small scales in island/reef systems across variable bathymetry its ability to predict the dispersal of hatchling marine turtles may add to its list of applications. Hatchling sea turtles enter the water soon after emergence from the nest and begin a swimming frenzy – a period of hyperactive swimming lasting around 24 hours. Hatchlings of most species of marine turtle have an oceanic dispersal phase and for these species it is believed that the swimming frenzy enables the hatchlings to reach the goal currents offshore. However, hatchlings of the flatback turtle remain on the Australian continental shelf and their dispersal from eastern Queensland rookeries is thus believed to be restricted to the lagoons and coastal waters of the Great Barrier Reef. Therefore in this study we used a SLIM to investigate its potential to map the offshore dispersal of hatchling flatback turtles from the largest flatback rookery in eastern Queensland. We ran the model six times, each for 14 days, with variation in tides (neap and spring), swimming (no swim or swim for 72 hours) and beach location (north and south). The model predicted that hatchlings dispersing from the southern beach, irrespective of tide and swimming, had a higher chance of remaining within the near shore area of the adjacent mainland to the south. In contrast, the model predicted that >80% of hatchlings dispersing from the

northern beaches ended up after 14 days in deep water (30–40 m) around 10 km north of the nesting beach. Our data demonstrate the power that predictive current modelling has to increase knowledge about a cryptic life stage.

*MIGRATIONS, HABITATS AND AT-SEA BEHAVIOUR OF HAWKSBILL TURTLES IN NORTHERN AUSTRALIA

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Despite its significant ecological role, its critically endangered status and its important cultural value for Aboriginal people, limited information is available on the hawksbill turtle in the Northern Territory of Australia. To fill this gap we investigated the nesting ecology and migratory behaviour of the population nesting on Groote Eylandt, a major nesting site for hawksbills in Northern Australia. The present paper reports the results of a satellite telemetry study and their implications for the effective management and protection of this turtle aggregation. Little is known of hawksbill migrations compared to other turtle species and even less is known of their diving behaviour. In particular, at-sea behaviour during migrations and at foraging grounds has been the subject of only one study to date. Determining hawksbill turtles' at-sea behaviour is central to understanding how they use their habitats and what physiological constraints drive their distribution and ecology. This information is critical for setting up effective conservation and management guidelines. In this study, seven adult female hawksbills were equipped with satellite transmitter units: three Platform Terminal Transmitters (PTTs) and four Satellite Relay Data Loggers (SRDLs). Fastloc GPS data along with high-quality Argos locations of classes A, 1, 2 and 3 were used and mapped with ArcView GIS. Diving data from the Time-Depth Recorders of the SRDL units was analysed using the R program and Eonfusion software. Results from satellite tracking show that the hawksbill turtles from Groote Eylandt live and feed in Australian coastal waters and migrate following the coastline, with the majority of the turtles tracked heading south once their nesting season was completed. The extent of these migrations ranged from 150 to 475 km (n=5 turtles). During the inter-nesting period, five out of seven hawksbills remained in the close vicinity of their nesting site (<30 km²), emphasizing the need to protect this important zone from fisheries during the nesting season. None of the hawksbills tracked settled down at the same foraging ground. Thus, a wide conservation effort along the vast North Australian coastline is required. Results from Time-Depth Recorders available so far (two turtles out of four are still currently migrating) show that the two hawksbills with small internesting areas (<2.5 km²) dived shallowly i.e. ≤10 m. On the contrary, the two hawksbills with a greater internesting area (177 and 1010 km²) dived deeper (mean max depth= 13.0 m (n=124 dives) and 31.7 m (n=24 dives). During their migrations, hawksbills displayed longer and deeper dives than during the internesting phase (mean max depth=9.05 m and 14.26 m, dive duration=19.67 min and 46.16 min respectively, n=2 turtles). These diving data along with habitat locations represent key parameters to protect this sea turtle population and must be taken into account in any future conservation plan.

TRANS-PACIFIC MIGRATION OF LOGGERHEAD TURTLE HATCHLINGS INFERRED FROM A NUMERICAL SIMULATION

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To examine the transport processes of loggerhead turtle (*Caretta caretta*) hatchlings during their trans-Pacific migration, we used Lagrangian numerical simulations. Our Lagrangian study was based on a high-resolution circulation field model developed by the Japan Agency for Marine-Earth Science and Technology. The model domain covers a near-global region extending from 75ºS to 75ºN except for the Arctic Ocean, with a horizontal grid spacing of 1/10º. To estimate the patterns of hatchling transport, 1,000 simulated particles were released from an area on the Pacific Ocean side of the Japanese coast, and tracked for 60 months (5 years) as passive tracers. Results

were as follows: 7.6% and 46.6% of the particles crossed the date line by six months and 12 months after the release, respectively, some of which reached 150ºW. The particles transported to waters north of 35ºN by six months after the release tended to be transported to the east, while many particles drifted to the south of 35ºN by six months and entered the North Pacific Subtropical Gyre. After 60 months, the particles reached a maximum range of about 124ºW and no particles reached the coastal area of Baja California (east of 120ºW), which is assumed to be a major developmental habitat of this species. It is suggested that loggerhead trans-Pacific migration could not be achieved only by passive processes and that active swimming after the first year is also important for migration. The results of the study also indicate that the North Pacific subarctic–subtropical transition region plays an important role in trans-Pacific migration, and that hatchlings have biological mechanisms to transfer themselves from the Kuroshio Extension to the transition region.

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*TRACKING NEONATE LOGGERHEAD (*CARETTA CARETTA*) SEA TURTLES USING SATELLITE TELEMETRY

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Early sea turtle behavior, dispersal, and habitat use are largely inferred rather than directly observed. Historically, available technology and tracking methods were limited by the small size and rapid growth of hatchling and neonate sea turtles. Using newly available small-scale solar-powered bird tags (9.5–12 g), we modified, developed and tested traditional and novel tag attachment methods specific to neonate loggerhead (*Caretta caretta*) sea turtles. We conducted laboratory trials testing different attachment methods for attachment duration and relative impacts to the turtles (≥240 g). Methods included traditional direct carapace attachments using hard epoxies, novel neoprene and silicone direct carapace attachments, and indirect neoprene and lycra harness attachments. Direct attachment methods were tested on turtle carapaces treated with manicure acrylic, and carapaces left untreated. Direct carapace attachments remained on the turtles' untreated carapaces from 7–36 days (mean=14.3 days ±8.6 SD). With an acrylic base-coat, attachments remained on turtles' carapaces for more than 60 days in controlled laboratory conditions. Harness and hard epoxy attachments also resulted in long-term tag retention (60+ days); however, these attachments did not adjust for turtle growth, resulting in a binding effect that, in some cases, temporarily altered carapace shape. Thus, the least invasive and longest retaining method was a silicone-neoprene attachment with an acrylic base-coat. We lab and field-tested "limited-toxicity" clear antifouling coatings on the performance, corrosion and fouling of surrogate solar cells. Finally, we field-tested the performance of seven solar-powered satellite bird tags on lab-reared neonate (13–18 cm SCL) loggerhead sea turtles. Turtles were released in the Gulf Stream current off the southeast coast of Florida (USA). There were no differences in daily charge rate of tags treated with an antifoulant (n=5) and those left untreated (n=2). This suggests that the antifoulant did not obscure or impact the solar cell's performance; cessation of transmissions was not due to lack of adequate charge. Tags transmitted for 38–85+ days (average 57 ±17 days SD). The majority of Argos location class codes (LC) received from the tags were of high location accuracy, ranging between LC 1–3 (64%), likely reflecting the surface-based behavior of the young turtles. With one exception, all turtles remained in or within close proximity to the Gulf Stream post-release. Turtles traveled along the frontal edges of the Gulf Stream off the eastern coast of the US. Several turtles continued east with the Gulf Stream into the northwestern Atlantic, transmitting within the Gulf Stream and associated eddies. One turtle departed from the Gulf Stream, swimming southeast to the waters off Bermuda. These data are the first successful satellite tracks of any posthatchling sea turtle and provide the first *in situ*, empirical evidence of neonate loggerhead movements in the Atlantic. Our data also suggest that small solar-powered bird tags are a viable tool for monitoring the in-water behavior of neonate loggerhead sea turtles. Funding and support for this project was provided by the Large Pelagics Research Center Extramural Grants Program, the National Academies Research Associateship program, the Ashwanden Family fund, Nelligan Sea Turtle Fund, Save Our Seas Foundation, and J. Abernethy.

EVIDENCE FROM GENETIC AND LAGRANGIAN DRIFTER DATA FOR TRANSATLANTIC TRANSPORT OF SMALL JUVENILE GREEN TURTLES

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Green turtle hatchlings disperse away from their natal location to spend an early pelagic stage in the ocean, followed by a neritic stage where small juveniles settle in coastal areas. Here, we combined genetic and Lagrangian drifter data to investigate the connectivity between natal and foraging locations; particularly focussing on the evidence for transatlantic transport. Our results supported the general hypothesis that turtles tend to select foraging areas 'closest-to-home'. Nevertheless, genetic analyses show that small juvenile green turtles are also capable of dispersing extensively, and some will drop out of the pelagic phase on a trans-Atlantic scale (average distance between natal and foraging locations = 3,048 km). Lagrangrian drifter data further demonstrated that transport by drift across the Atlantic within a few years is possible.

*OCEANOGRAPHIC FACTORS DETERMINING THE POST-NESTING MIGRATION OF OLIVE RIDLEY TURTLES IN THE BAY OF BENGAL

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Tracking 32 post-nesting olive ridley turtles fitted with Platform Terminal Transmitters (PTTs) from the Orissa coast in January to August 2009, we determined their migration paths in the Bay of Bengal based on 8,213 geolocations. Filtering the geolocation data based on quality classes, we linked 5,301 good quality data points to sea surface currents, 4,749 to sea surface temperature (SST), 2,905 to wind speed and direction and 1,242 to chlorophyll a to examine the factors that may determine the migratory paths of olive ridley turtles from and to the Orissa coast. While examining migration patterns and sea surface currents, we found that at a broad scale turtles migrate against water current patterns. However, no specific relationship was found between turtle migration path and surface water currents. Sea surface currents appear to be circular at the local scale and turtles also seem to follow this pattern. With respect to SST, migratory turtles remained within a range of 22.34°C and 31.59°C (28.43 ± 0.02°C). About 73% of turtle locations were in locations where the wind direction was toward the northeast, with an average wind speed of 26.1 km h^{-1}. With respect to chlorophyll a, migratory turtles remained within the range of 0.05 to 7.63 mg m^{-3}, with mean chlorophyll a at 0.54 ± 0.03 mg m^{-3}. Although water currents, wind speeds, sea surface temperatures and chlorophyll concentrations in the marine environment appear to determine the migration path of olive ridley turtles, the present data show that the migration routes and foraging habitat of these turtles is likely to be generalized in nature in the Bay of Bengal.

*SHOULD I STAY OR SHOULD I GO: OLIVE RIDLEY POST-NESTING MIGRATIONS

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The population of olive ridley turtles (*Lepidochelys olivacea*) nesting on Masirah Island, Sultanate of Oman, is the only one in the Arabian region, with an estimated 150 females nesting per year. During the 2008 nesting season, we attached nine Argos PTTs to females after laying, in order to ascertain migratory behaviour and foraging locations of this poorly studied population. Mean curved carapace length (CCL n-t) of tagged individuals was 74.1 cm (SD 1.6, range 71–76 cm, n=9). After departing the nesting area, three turtles remained within 100 km of Masirah, in waters to the south west, averaging less than 30 m deep, for the duration of their transmissions (26–141 days). A total of five turtles migrated north. Three of them travelled over 600 km, one to coastal waters of Pakistan and the other two to territorial waters of Iran, UAE and Oman at the entrance to the Arabian Gulf. The destinations of the other two northern turtles averaged less than 130 km from the nesting area and the turtles remained in shallow, coastal waters (average 31 and 22 m deep). The final turtle, one which did not settle, moved into oceanic waters east of Masirah for 97 days before entering neritic waters to the south. Olive ridleys from Oman display unusual behaviour for this species with the majority of turtles residing in shallow neritic waters. This contrasts with adult olive ridleys from Costa Rica and India, which have been shown to have a largely oceanic existence. Individuals from northern Australia have been shown to be able to feed on the sea bed in waters 100 m deep and olive ridleys have been recorded to dive as deep as 300 m. Evidently, some olive ridleys nesting on Masirah exploit shallower foraging areas than their conspecifics. This finding broadens the observation that olive ridley diets are highly variable between regions. With six of nine turtles remaining within Omani waters after breeding, it is clear the country has a vital role in maintaining this unique population. Unregulated fishing activity or habitat degradation in near-shore waters will impact upon the biologically valuable adult age class. AFR wishes to thank the symposium organisers for travel assistance that enabled participation at the 30th ISTS.

*NEST SITE FIDELITY OF CUBAN GREEN TURTLES (*CHELONIA MYDAS*) AND ITS IMPACT IN THE MANAGEMENT OF THE SPECIES

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The degree of nest site fidelity of all tagged females in the G. Peninsula, Cuba, was determined both within and among nesting seasons by registering the distances between subsequent nesting attempts. During the same season, only 6.3% of the turtles were observed nesting on more than one beach. Of these movements, 99% were less than 25 km and 80% were less than 15 km. Of the 113 observed remigrants, 12 returned to a different beach, representing 10.6% of the total. Most of the remigrations to different beaches occurred after the impact of large hurricanes such as Ivan in 2004. Nest site fidelity reflects genetic differentiation at a micro-geographic scale within the Peninsula. The exceptions to the nest site fidelity occurred among adjacent beaches, which constitute a unit from the genetic point of view. The particular geographic distribution of rookeries in the southwest region of Cuba and their accessibility with respect to ocean current patterns, together with beach characteristics, contribute to genetic differentiation and high levels of haplotype endemism found, to the point of generating longitudinal gradients in

haplotype distribution. The correct identification of beaches with appropriate conditions for *Chelonia mydas* nesting will make it possible to focus conservation efforts. At the same time, combining physical tagging with population genetics will enable adequate definition of management units to guarantee the preservation of the genetic variability of the species.

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*SATELLITE TRACKING SUGGESTS SIZE-RELATED DIFFERENCES IN BEHAVIOUR AND RANGE OF FEMALE GREEN TURTLES NESTING AT REKAWA WILDLIFE SANCTUARY, SRI LANKA

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Phenotypically-linked variation in adult foraging and migration strategies have been determined in loggerhead turtles (*Caretta caretta*) and have been suggested in green turtles (*Chelonia mydas*). This study deployed satellite transmitters on ten female green turtles at Rekawa Wildlife Sanctuary, Sri Lanka's largest protected green turtle rookery and, for the first time, tracked the post-nesting movements of the island's green turtles. The tracking revealed multiple adult female green turtle inter-nesting, migration and likely foraging strategies. The curved carapace lengths (CCL) of the tracked turtles were representative of Rekawa's nesting females, and ranged from 90.1 cm to 117.5 cm, with a mean of 102.8 cm (SD 8.2 cm). During the nesting season, the turtles revealed two distinct inter-nesting strategies, which appeared to be related to size. While one turtle migrated away from Rekawa immediately after the transmitter was deployed, most turtles (n=6) consistently spent their inter-nesting periods proximate to the nesting beach. However, three of the smallest turtles consistently migrated to three separate inter-nesting sites within 60 km straight-line distance from Rekawa along the southern coast of Sri Lanka. On completion of their nesting seasons, these turtles then migrated back to these coastal sites where they settled before their transmitters failed. The six largest turtles migrated to distant sites between 355 km and 1,128 km straight-line distance from Rekawa where they settled at shallow coastal sites. One turtle, with a CCL of 92.8 cm, did not conform to the general pattern, but migrated to an oceanic island located a straight line distance of 898 km from Rekawa. Unlike all the other turtles in this study, this turtle did not settle at a shallow coastal foraging site, but instead made frequent, looping pelagic forays before the transmitter failed, suggesting a completely different foraging strategy to the other tracked turtles. We discuss the possible reasons for these apparent size-related variations in inter-nesting, migration and foraging behaviour and suggest conservation implications.

IDENTIFICATION OF HIGH-USE INTERNESTING HABITATS FOR EASTERN PACIFIC LEATHERBACK TURTLES: ROLE OF THE ENVIRONMENT AND IMPLICATIONS FOR CONSERVATION

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Eastern Pacific leatherback turtles (*Dermochelys coriacea*) have declined by up to 90% in the past two decades. Egg harvesting was determined to have been the largest causative factor but since this has been eliminated, high estimated adult mortality from fisheries bycatch poses the single greatest threat to this population. During the nesting season, adult female leatherbacks nest multiple times, occupying coastal marine habitats near their nesting beaches. In this study, we characterized the interannual variability of high-use internesting habitats utilized by 44 (from 46 total) female leatherback turtles satellite-tagged at Playa Grande, Costa Rica during 2004 to 2007. A total of 1,135 days of internesting movements were recorded across three tracking years. The core 25% utilization distribution (UD) remained predominantly centered within a marine protected area, Parque Nacional Marino Las Baulas (PNMB). The turtles generally dispersed in a northward or southward direction over the shallow continental shelf framing Costa Rica's Nicoya Peninsula. However, there was considerable interannual variation in the shape and area of the larger UD polygons, driven by variability in the thermal environment. The maximum swimming speeds and distance traveled from the nesting beach occurred during 2007. Significantly deeper and longer dive durations to cooler temperatures also occurred in this year, which may have been in response to the warming trend from the south driven by the strong Costa Rica Coastal Current. Our findings therefore validate the importance of PNMB for internesting leatherbacks, but also suggest that a latitudinal expansion of the marine portion of the park is warranted.

A NEARLY GAP-FREE PORTRAIT OF GREEN TURTLE DEVELOPMENTAL STAGES WITHIN A SINGLE REGION

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Green turtles occupy many widely separated developmental habitats during a decades-long period of maturation. One result of this separation is that no single habitat or location has members of all life stages present. Because regional green turtle populations have life stages distributed among multiple locations and habitats, researchers have been unable to access complete (gap-free) representations of life stages. For example, difficulty in accessing open-ocean habitats has meant that early pelagic/oceanic green turtle stages are missing from regional data sets. In this study, we describe a unique, nearly gap-free series of life stages for green turtles from the waters of the Atlantic and Gulf of Mexico surrounding the Florida peninsula USA. We present size-class distributions for green turtles captured as post-hatchlings, juveniles, subadults, and adults. Capture locations include (in order of mean carapace length): A) summer captures from Atlantic pelagic Sargassum, B) fall storm recoveries from Atlantic Sargassum, C) captures from Gulf of Mexico pelagic Sargassum, D) winter captures from nearshore Atlantic hard-bottom near the St Lucie Power Plant (SLPP), E) captures from shallow seagrass near the Marquesas Keys, F) summer captures of immatures at the SLPP, G) captures from the southern Indian River Lagoon, H) captures from deep seagrass near the Marquesas Keys, I) summer nesting season adult captures at the SLPP, and J) females on Atlantic nesting beaches at southern Brevard County. We describe green turtle life stages by size, realm (terrestrial, pelagic, benthic), zone (supralittoral, neritic, oceanic), and hypothesized behavior (foraging, migrating, breeding). Mean standard straight

carapace length (cm, notch to tip) (SD, n) for each of the ten green turtle groups (A–J above) was: 5.4 (0.1, 14), 5.7 (0.5, 87), 21.3 (1.6, 29), 39.3 (11.2, 2379), 42.2 (7.9, 122), 44.5 (15.2, 2807), 51.4 (10.5, 226), 88.2 (11.3, 45), 94.1 (6.4, 136), and 101.5 (5.7, 27). The only gap in the size-class distribution was 8–19 cm, a stage likely located in the oceanic environment. Because two other significantly different sizes of open-water, pelagic neonates are known from the waters off Florida, this gap indicates that green turtles in the region have at least three pelagic/oceanic developmental stages and/or locations. The seasonal size distribution of green turtles captured at the St Lucie Power Plant shows at least three overlapping groups (indicated by modes in the size distribution): winter juveniles (which are smaller and may include recruits from the pelagic habitat), summer juveniles (which are larger than winter juveniles and are recaptured at a higher rate), and breeding adults (observed only during the summer nesting season). Turtles from the Key West Refuge include two geographically close but discreetly separated groups: juveniles and subadult/adults. We do not know how many genetic stocks make up these regional groups, but analyses are underway. The complexity of green turtle assemblages has implications for representative sampling for genetics and other biological information.

REPRODUCTION

NESTING ECOLOGY, HATCHING SUCCESS AND CONSERVATION OF SEA TURTLES IN ADA FOAH, GHANA

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Nesting ecology and the hatching success of sea turtles in Ada Foah were investigated from October 2007 to September 2008 along a 9 km stretch of beach. Beach morphology and sand characteristics were also assessed and related to the nesting activity observed. Univariate and multivariate techniques were employed in the data analyses. Leatherback (*Dermochelys coriacea*) and olive ridley (*Lepidochelys olivacea*) were the two turtle species found to nest in the study area. The olive ridley deposited 103 nests while the leatherback deposited 74 nests over the study period. The mean clutch size was 81 eggs/nest and 119 eggs/nest for the leatherback and olive ridley respectively. Mean incubation period was 59.3±5.7 days for leatherback and 60.3±5.0 days for olive ridley. Hatching success was 79.3±11.6% for leatherback and 86.8±4.1% for olive ridley. Beach slope influences nest site selection among the olive ridley turtles. The hatching success was also influenced by the sand characteristics of the area. Predation by dogs was the major threat to nests in the area accounting for over 50% of the total nests destroyed. The Ada Foah beach is a fast eroding and a very dynamic sandy beach. This threatens the use of this area as a nesting site for sea turtles through habitat loss. A sea defense project is recommended in the area as well as the construction of a hatchery (as a short term measure) to help solve the problem of nest predation in the area. Long term monitoring of the populations of nesting turtles is also recommended.

*THIRTY-NINE YEARS OF HAWKSBILL TURTLE EFFECTIVE PROTECTION AND MONITORING: THE SUCCESS OF COUSIN ISLAND SPECIAL RESERVE, SEYCHELLES

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The Seychelles, in the Western Indian Ocean, is home to one of the most important remaining populations of hawksbill turtles. Cousin Island, one of 115 islands that make up the Seychelles Archipelago, has been monitoring their nesting population since 1970, making it one of the longest running monitoring programmes worldwide. Here, we report trends in annual nesting numbers from 1973 to 2009 in addition to inter-island migrations and nesting success between 1999 and 2009. Turtles were individually tagged and data were collected both on turtles sighted and from indirect evidence of nesting attempts where individual females were not seen. Monitoring intensity varied over the seasons, particularly during 1999–2006, thus a Poisson distribution was fitted to data on numbers of times each individual was seen at this breeding site in a season, and used to estimate the number of unseen individuals and therefore the total number of nesting females in that season. Intensive data collection between 2006 and 2009 confirmed the estimated figures from the earlier seasons. Results show an eight-fold increase in the number of nesting turtles since monitoring began in 1970 and a higher mean nesting success rate (51%) relative to other nesting beaches within the Western Indian Ocean (around 30%) where nesting success refers to the laying of a clutch of eggs. Furthermore, inter-island migrations between Cousin and its neighbouring island, Cousine, are common but with a greater proportion of Cousine's turtles migrating to Cousin relative to their total annual nesting numbers. Conservation and management efforts to aid the recovery of the hawksbill turtle population on Cousin Island have been hugely successful. This is largely due to the long-term protection they have been afforded both in-water and on the nesting beaches since 1968 when ownership of the island was handed over to a conservation NGO, as well as restoration of the native vegetation and maintenance of an environment free of alien predators such as rats and cats. Furthermore, Cousin Island's locally operated ecotourism business helps to support a wide variety of local businesses on neighbouring islands, providing economic benefits to communities that may have previously relied on poaching as a source of income or food.

IMPACT OF EROSION ON HATCHING SUCCESS IN MASS NESTING SITES OF OLIVE RIDLEY TURTLES ALONG THE ORISSA COAST, INDIA COAST, INDIA

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Onshore habitats are critically important in the life history of female olive ridley sea turtles. Therefore we carried out studies on the onshore habitats of Gahirmatha, Devi and Rushikulya rookeries during 2009 nesting season. We compared data with long-term beach profile work carried out in the Gahirmatha, Devi and Rushikulya mass nesting sites. Study shows that the Gahirmatha mass nesting beach is eroding at a faster rate over the years, compared to the other two nesting sites. Although mass nesting took place in Gahirmatha and Rushikulya, our study found that erosion and inundation was found to be the major reason for the significant difference in the hatching success at Gahirmatha (20.4% ± 17.9%) compared to Rushikulya (89.5% ± 10.3%). However, Gahirmatha has shown over the years a decline in the hatching success of eggs laid during the arribada. Uncertainty in the success of Gahirmatha rookery means the long-term conservation of olive ridley sea turtles in India is now a serious concern.

NESTING STRATEGIES OF THE LOGGERHEAD SEA TURTLE (*CARETTA CARETTA*) IN SOUTHEASTERN NORTH CAROLINA

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Internesting and interseasonal nesting patterns were determined for loggerhead sea turtles (*Caretta caretta*) on Bald Head Island, North Carolina, from 1991 to 2000. Bald Head Island is one of the northernmost nesting regions for loggerhead sea turtles along the East Coast of North America, which has important implications affecting sex ratios in regions experiencing climate change. Three hundred and twenty-eight nesting females were tagged with Inconel flipper tags over the 10-year study period. Females were observed laying 823 of 1,012 nests, an annual intercept rate of 81.6%, which did not vary significantly among years. Three types of sea turtle nesting behaviors were identified for the nesting beach: one-time nesting females, one-season nesting females, and multiple-season nesting females, making up 59.5%, 24.1%, and 16.5% of the nesting females tagged, respectively. These percentages varied significantly over the 10-year study period, as did the total numbers of nests laid by each type of nesting female. One-time nesting females laid 195 (23.7%) of the observed nests. One-season nesting females laid 240 (29.2%) of the observed nests. These females laid an average of 3.0 nests per female with significant variation among years. Multiple-season nesting females laid 389 (47.3%) of the observed nests. These females laid an average of 2.7 nests per female with significant variation among years. Internesting intervals (mean 13.8 days) varied significantly among years. Interseasonal intervals (mean 2.7 years) varied significantly among years but given the short duration of the study period it was not possible to statistically compare years with confidence. Most (84.4%) of the multiple-season nesting females nested every-other year and every-third year. Understanding these three reproductive strategies is critical in developing management plans for this protected species.

THE EFFECT OF INCUBATION TEMPERATURES ON THE HATCHING SUCCESS OF LOGGERHEAD SEA TURTLES (*CARETTA CARETTA*) IN KWAZULU-NATAL, SOUTH AFRICA

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Incubation temperatures in sea turtle nests are never constant and are affected by a range of factors including shading, seasonal temperature fluctuations, sand colour, rain, depth of eggs etc. South Africa has an exceptional long-term monitoring programme focusing on nesting female loggerheads, but field-based studies concerning the

effects of temperature on population demography and survival have not been conducted. The purpose of this study is to examine the effect of incubation temperatures on the hatching success and sex ratios of the loggerhead (*Caretta caretta*) sea turtle population in South Africa, northern KwaZulu-Natal. The study focuses on a 5 km beach stretch which is the peak nesting site for loggerhead turtles. During the peak nesting season in December, temperature data loggers were deployed in the nests while egg-laying took place. The data loggers were retrieved and nests were excavated after hatching took place during hatching season (February/March). By examining the nest contents the nest success (i.e. successful nest versus depredated or inundated nests), hatching success and emergence success was determined. Temperature results for the first season (December 2008 – March 2009) indicate that the mean incubation temperature was 29.6°C (n = 10), and the overall nest success was high (93.6%, n = 110). However, nests that contained temperature data loggers (n = 20) showed poor nest success (50.0%). Preliminary temperature results for the second season (December 2009 – March 2010) indicate mean incubation temperature as 29.9°C (n = 9) and shows high nest success of 93.7% (n = 174). Similarly to the previous season, nest success for temperature monitored nests hitherto, indicate poor nest success of 47.4% (n = 19). Temperature monitored nests where the middle third of incubation could be calculated showed mean nest temperatures of 29.7°C (n = 6 for 2008/9) and 29.7°C (n = 9 for 2009/10). Whether temperature data loggers possibly lure nest predators or poachers is not well established. Heavily depredated nests were excluded from statistical analyses of hatching- and emergence success. The mean hatching- and emergence success was 82.0% and 80.8% (n = 85, 2008/9); 79.5% and 78.6% respectively (n = 168, 2009/10). Unsuccessful nests and low hatching success were largely due to high depredation. For the first season, temperature results indicated no significant correlations ($p > 0.05$) between incubation temperature and (a) nest-, hatching- and emergence success; (b) physical parameters including nest depth, elevation. No statistical analyses have been conducted for the second season. Assumptions are that the sex ratios for this population may be female-biased due to the high temperatures turtle eggs experienced during the thermal sensitive period. High nest success may be attributed to the strict beach access and control during peak nesting season. These results may suggest a positive turtle population recovery due to the long-running turtle monitoring programme in KwaZulu-Natal. However, multiple seasons of data and larger sample sizes may give a better insight to the mechanism(s) contributing to successful and unsuccessful clutches. The status of loggerhead turtle populations in South Africa needs to be re-evaluated.

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*INFLUENCE OF TEMPERATURE AND BEACH MOVEMENT ON DIFFERENTIAL SURVIVAL PROSPECTS FOR LEATHERBACK AND LOGGERHEAD TURTLES SHARING A COMMON NESTING BEACH IN MAPUTALAND, SOUTHERN AFRICA

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The leatherback sea turtle (*Dermochelys coriacea*) nesting colony situated in Maputaland, southern Africa, is the most isolated and furthest from the equator in the world, putting it at one on the extremes of their existence. Population monitoring and protection of this nesting population has been continuous since 1963, after reports of escalated turtle harvesting by local communities. A steady increase in nesting numbers over the first 11 years of conservation and protection efforts was seen, but has since stabilised at relatively low levels. Loggerhead sea turtles (*Caretta caretta*) nesting at the same site, however, have demonstrated steady population growth over the entire 46 years. Why have leatherbacks not benefitted as much as loggerheads from this long-term protection? Erosion on this highly energetic beach front, and differing sex ratios could be contributing factors to this minimal success. Leatherbacks nest lower down on the beach profile than loggerheads giving them greater exposure to the impact of tidal erosion and deposition, and different beach temperature regimes. In our study, beach profiles were measured throughout the duration of a nesting season at six different sites along the nesting beach. Over any 70 day period there was an average of 0.62 m (S.D. 0.15 m; range 0.34–0.85 m) deposition and 0.42 m (S.D. 0.17 m; range 0.14–0.71 m) erosion from the starting surface level at suitable leatherback nesting areas at the sites, and 0.36 m (S.D. 0.12 m; range 0.15–0.51 m) deposition and 0.34 m (S.D. 0.12 m; range 0.21–0.61 m) erosion at suitable loggerhead nesting areas. Average depth to the top of the nest for successful leatherback nests was 66.15 cm (S.D. 18.86 cm; range 15–107 cm), while for loggerheads it was 55.5 cm (S.D. 12.89 cm; range 28–110 cm). This would put both species at risk of having their eggs exposed and destroyed, but to a greater extent the leatherback. Temperature was measured at 3 sites along the nesting beach, with 9 probes situated at three depths and three distances from the shoreline per site. The difference between the temperature at 50 cm in the upper profile, nearest to the average

loggerhead nesting site, and at 75 cm in the middle profile, nearest to the average leatherback nesting site, was on average 0.77°C, which could make a vast difference in temperature-dependent sex determination (TSD) between the species. Incubation temperature was measured within six successful leatherback nests using I-Button data loggers. The average temperature during the critical period for sex determination of the middle third of incubation was found to be 29.04°C (S.D. 0.86°C; range 27.62–29.69°C). The difference in temperature between loggerhead and leatherback nesting sites could drastically affect the sex ratios between populations, especially with leatherback critical period temperatures being so close to the possible pivotal temperature of 29.4°C.

*A LONG-TERM STUDY ON THE MAJOR FACTORS THAT INFLUENCE NEST TEMPERATURE DURING EMBRYOGENESIS ON WAN-AN ISLAND, PENGHU ARCHIPELAGO, TAIWAN

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Season, precipitation, nest depth and metabolic heat production are the major factors that influence nest temperature of sea turtles during embryogenesis. Air temperature during the mid-summer, by influencing the sand temperature, affects the nest temperature more than the beginning and the end of the nesting season. Precipitation and huge waves during a typhoon can cause a dramatic drop in nest temperature. Daily variation of sand temperature decreases with depth, at less than 0.5 ºC below 40 cm. However, metabolic heat increases with embryogenesis and highest temperatures are reached just before hatching. Results of the field studies from 1996 till 2009 on Wan-an Island, Penghu Archipelago, Taiwan, showed that the sex ratio of the green turtle hatchlings from this island was estimated to be 70 to 90% females. Metabolic heating can reach 4.8 ºC in the final stage of incubation, which was significantly higher than the other periods. Hatching success, however, was not influenced by changes in nest temperature. On the other hand, the frequency of carapace abnormalities seems to have increased in recent years. This long-term study provides detailed information on nest temperature during the embryogenesis, which is important to the understanding of the impact of global climate change on sea turtle populations.

FACTORS THAT INFLUENCE CHANGES IN OXYGEN CONTENT OF GREEN SEA TURTLE NESTS DURING EMBRYOGENESIS ON WAN-AN ISLAND, PENGHU ARCHIPELAGO, TAIWAN

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The biological and non-biological factors influencing nest oxygen content were determined during each developmental stage of green sea turtle embryos on Wan-an Island, Penghu Archipelago Taiwan. The oxygen content in 7 nests in 2007 and 11 in 2008 were determined. Oxygen in the adjacent sand, total and viable clutch sizes, air, sand and nest temperatures and sand characteristics of each nest were also determined. The nest oxygen content decreased with embryogenesis, lower in late stages than the early and middle stages. The nest oxygen content was also lower in the middle layer than the upper and bottom layers. Nest temperature showed opposite trends, reaching its maximum value in late stages of development. Nest oxygen content was influenced by viable and total clutch sizes, air and sand temperatures, maximum nest temperature and maximum change in the nest temperature during the incubation. Among these factors, clutch size was the major influential factor. However, the major influential factors were different for different developmental stages. In the first half of incubation the development rate was low and the change in the nest oxygen content was influenced mainly by air temperature and by clutch size. During the second half of incubation, the high embryonic development rate became the dominant factor, and hatchling activities caused greater oxygen consumption during the last stage of development.

NESTING ECOLOGY OF THE HAWKSBILL TURTLE, *ERETMOCHELYS IMBRICATA*, IN ABU DHABI, UAE

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Two species of sea turtle, the hawksbill (*Eretmochelys imbricata*) and the green (*Chelonia mydas*), predominantly occur in the waters of the Emirate of Abu Dhabi, UAE. Both the species extensively use UAE waters for foraging and one species, the hawksbill, nests on the sandy beaches that have outcrops of vegetation on at least 17 offshore islands. Hawksbill turtles nesting in Abu Dhabi were monitored during the nesting seasons from 2000 to 2009. The nesting season extends from March to June with a peak between middle of April to middle of May. Inter-annual nesting varies from 152 to 200 nests. Adult females averaged 69.6 cm and 63.1 cm in curved carapace length and width respectively. Hatchlings emerge between the last week of May and last week of July. Average clutch size per nest was 57.2 (range: 32 to 119) eggs with 6.8 (range: 4 – 24) unfertilized (yolkless) eggs per clutch. Mean incubation period was 55.4 (range: 43 – 71) days with an average hatching success at 51.4% when calculated as percentage of total number of eggs. Eggs weighed an average of 32.5 g and measured an average of 38.6 mm diameter. Hatchlings weighed 12.62 g (range: 8.9 g to 16.9 g on day 1) and measured 3.69 cm and 3.61 cm in curved carapace length and width respectively. The presentation elaborates results of a long-term study of nesting ecology of hawksbill populations of UAE within the Arabian Gulf.

NESTING ECOLOGY OF THE LEATHERBACK TURTLE, *DERMOCHELYS CORIACEA*, ON BIOKO ISLAND'S SOUTHERN BEACHES, EQUATORIAL GUINEA, AFRICA

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There are five distinct nesting beaches on Bioko Island's southern coast that are separated by rocky coastlines and volcanic outcroppings. These nesting beaches are situated in the 510 km² Grand Caldera Scientific Reserve, which contains only one small village known as Ureca. Four different species of turtles nest along these shores: leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*) turtles. Since 2000, Bioko Biodiversity Protection Program (BBPP) has been working with the community of Ureca to collect data on the number of nests per season of all four turtle species. In January 2008 BBPP began collecting nesting ecology data in conjunction with an intensive tagging program on Playa de Moaba, one of the five nesting beaches. All female leatherbacks nesting on Playa de Moaba were tagged with Passive Integrated Transponder (PIT) tags for identification, allowing the number of turtles as well as the number of nests per turtle to be recorded. Mean clutch size, egg mass, standard curved carapace length, and standard curved carapace width were calculated. Upon hatching, the mean number of hatchlings and hatchling weight, straight carapace length and straight carapace width were calculated. The nests were then excavated and developmental stages of un-hatched eggs were determined. This is the first time this type of data is available for this population and it is unclear whether the population is increasing or decreasing. Due to the surrounding steep terrain, intense surf and lack of development around the nesting beaches, egg-poaching does not currently pose any serious threat on Bioko Island. However, the rapid development of the country could quickly change this situation. Continued monitoring is necessary to determine the population's growth trend, especially with the potential threat of environmental degradation due to oil and gas extraction practices throughout the Gulf of Guinea.

KEMP'S RIDLEY NESTING ON THE TEXAS COAST: ASSIGNING NESTING FEMALES TO UNKNOWN NESTS USING MICROSATELLITES

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There has been a significant increase in nesting by Kemp's ridley sea turtles at Padre Island (PI) and nearby beaches in Texas. Since 1995, the number of nests recorded in Texas increased from 4 to a record of 195 in 2008. This is in part the result of a long-term experimental program that involved "imprinting" hatchlings on PI that had been hatched from eggs relocated from the main nesting beach at Rancho Nuevo, Mexico. Although nests are identified and monitored in Texas, it has not been possible to observe and tag each nesting female along the extensive stretch of coastline. It is unclear how many nests were laid by the same female turtles, and this information is important to obtaining an accurate estimate of the annual numbers of females nesting. We explore using a genetic approach to inferring the number of individual nesters from genotypes determined from dead embryos and hatchlings sampled from clutches laid in Texas. We have developed and optimized 11 microsatellite loci for Kemp's ridleys to match genotypes for nesters and offspring of unknown parentage. Analyzing approximately 100 nests, where the mother is unknown, we have been able to match just over 50% to a sampled nesting female. We evaluate whether microsatellites are a useful tool in determining how many females are nesting in Texas. Results will be used to address management questions regarding abundance of nesting females.

*A PHYLOGEOGRAPHIC ANALYSIS OF *CHELONIA MYDAS*: PRELIMINARY RESULTS

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Numerous investigations have determined the genetic structure of different populations of *Chelonia mydas* (Cheloniidae) throughout the world. However, to date there has not been any study which analyzes on a global scale the abundance of mitochondrial DNA haplotypes characteristic of nesting populations, to understand both their genetic interactions and their possible dispersal through time and history. The present meta-analysis, based on 14 publications, reviewed 536 bp long fragments from the mtDNA control region of a total of 80 haplotypes represented by 3,067 individuals, which, according to their origin, were grouped into 11 geographical regions: Caribbean, West-Atlantic, Central-Atlantic, East-Atlantic, Mediterranean, West-Indian, East-Indian, South-East-Asia, West-, Central- and East-Pacific. This meta-analysis constructed a phylogenetic network, based on 2,750 mutations, which revealed 11 clades; six belonging to the great region of Australasia and/or Indian Ocean, four to the Atlantic and one to the eastern and central Pacific. An analysis of molecular variance (AMOVA) and genetic diversity estimates was congruent with network results. The results show multiple origins for the regional populations. Three independent introductions were identified for the Atlantic to the Indian Ocean and Australasia, and one colonization from the Pacific to the same region. Genetically, the most distinct region is the eastern Pacific, which, according to previous reports separated from the Atlantic populations about 7 million years ago. Based on this assumption the present investigation reconstructed the changes in oceanic conditions and habitat availability which led to the global dispersal patterns of *Chelonia mydas*. This work emphasizes those changes which may have caused the separation of Atlantic and Pacific populations on morphological and physiological adaptations to the eastern Pacific environment. This work could not have been completed without the major support of Eric Fuchs. Also, I would like to thank Gabriela Chavarría, Randall Arauz, Kelly Stewart, Nancy FitzSimmons, Brian Bowen, Rotney Piedra, Peter Dutton and Peter Meylan for any comment, advice and support. Many thanks to the International Sea Turtle Society for making possible the presence of this work in the present symposium.

COMPARING MULTIPLE PATERNITY IN OLIVE RIDLEY (*LEPIDOCHELYS OLIVACEA*) NESTING POPULATIONS ON THE EAST COAST OF INDIA

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This study compares multiple paternity between mass nesting (arribada) and solitary nesting olive ridley sea turtles (*Lepidochelys olivacea*) on the east coast of India. Arribada nesting is a behavior unique to ridley turtles, in which females congregate to produce clutches, nesting both diurnally and nocturnally. This behavior is in contrast to typical turtle nesting, in which solitary females nest exclusively nocturnally. Arribada nesting is thought to be a predator-swamping strategy. We will use microsatellites to analyze multiple paternity within and between populations. We will use two microsatellites that are variable among individuals, and two that maintain a single genotype within a breeding population. The greater the number of male turtles contributing to clutches in a nesting population, the more genetically diverse a population will tend to be. If multiple paternity is positively correlated with arribada nesting, this trend will manifest in similar sample sizes, and not just because arribada populations are larger than solitary nesting populations. A similar study of this species on the Pacific coast of Costa Rica found significantly greater levels of multiple paternity per clutch and per nesting population in clutches from arribada versus solitary nesters. Our project focuses on a population that is particularly vulnerable to fisheries-related mortality. Adults from the arribada nesting populations are particularly subject to capture in trawl and gillnet fishing operations in the Bay of Bengal. Adult olive ridley mortality has been estimated from approximately 14,000 per year, to 2,000 nesting females per month during peak nesting season, since 1983. Adult females are particularly vulnerable to bycatch mortality during nesting season, and mortality estimates have continued to increase since the mid-1990's. Arribada nesting has been absent for several years at two of the three arribada sites, including at one site fully protected as a wildlife sanctuary. Mechanized fisheries bycatch is implicated as a prime cause of this decline. The study population is thought to be ancestral to the species. If the results of this study indicate a positive correlation between arribada nesting and multiple paternity, as has a previous study in the eastern Pacific, this will provide evidence that such a relationship exists at the species level. If results indicate no correlation or negative correlation between arribada and multiple paternity, it will indicate that these aspects of olive ridley behavior and genetics have evolved differentially between breeding populations. The study will also illustrate how nesting strategy, and the location of fisheries operations, determine bycatch mortality risk in a nesting population. This information will help to inform and advocate for more effective conservation measures for the study population and region, as well as for the species.

POPULATION GENETICS OF GREEN TURTLES (*CHELONIA MYDAS*) IN MALAYSIA BASED ON MITOCHONDRIAL DNA SEQUENCES

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Knowledge of genetic structure among sea turtle rookeries enables us to define demographically discrete breeding populations and to clearly understand how they are related through gene flow. This information is vital for the implementation of effective conservation and management strategies for endangered species. This study examined the genetic structuring through analysis of mtDNA sequences of green turtle samples from six major nesting beaches in Malaysia. Fourteen haplotypes were detected, with overall haplotype and nucleotide diversity of 0.67 and 0.0056, respectively. Through this analysis, five genetically distinct breeding populations of green turtle were identified. These populations were also identified to be genetically distinct from the green turtle populations in western Pacific (Moritz *et al*. 2002) and Atlantic-Mediterranean (Encalada *et al*. 1996). These breeding units represent the logical focus for population recovery efforts. This is because breeding populations that are different in their genetic make-up are likely to exchange few individuals and will also respond separately to impacts and management action. Thus, to ensure the future survival of these populations, efforts should be made to protect the remaining nesting colonies as independent demographic entity. Phylogenetic analysis also confirms that the Malaysian green turtles are from the same evolutionary lineages with the green turtle from the Pacific.

*SPATIAL AND TEMPORAL VARIATION IN SEX RATIO ESTIMATIONS: THE CASE OF DALAMAN BEACH, MUGLA-TURKEY

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The nesting activities of loggerhead turtles were recorded on Dalaman beach, one of the main nesting grounds in Turkey during the years 2002–2008. The total number of emergences was 2,620 and 645 (25%) of them resulted in nests. The distribution and fate of the nests together with hatching success were investigated and the locations of nests were marked on maps together with beach-back structures. The incubation period of nests varied between 40 and 67 days with a mean of 49 days. The clutch size of nests ranged from 18 to 150 eggs with a mean of 79 eggs. The percentage of hatching success was 79.7% (min: 0, max: 100%). The sand and nest temperatures were recorded with electronic temperature recorders. The sand temperatures were found to be lower close to the sea and showed an increase towards inland. The intra-nest variations, inter-nest variation and sand temperatures at nest depths at 128 locations were recorded. The mean temperatures were 30.5 at the bottom, 31.3 at the middle and 31.6 ºC at the top levels. The mean temperatures at the first, middle and last third of the incubation period were 29.4, 30.1 and 30.7 °C respectively. The estimated sex ratios of females for the temperatures taken for these duration were 60% at the first third, 69% at the middle third and 78% at the last third periods. The mean of sex ratio for the mean of the entire incubation temperature was 75%. The sex ratio of dead hatchlings and embryos was determined by histological examination of the gonads and the mean sex ratio obtained was 70% females (n=490). The majority of the embryonic mortalities were found at early (6–7) and late (>26) stages. When these embryonic mortalities were compared in terms of depths, the highest percentages were found at middle (45%) and lower (35%) levels of the nests and less mortality (20%) in the higher levels. When the sex ratio of dead hatchlings and embryos is compared between the different levels, a 90% female sex ratio was obtained at the upper level, but female sex ratio was 82% and 50% at the mid and lower levels respectively. The spatial and temporal variations of nests and their sex ratios were discussed under the possible effect of beach back structures to the nesting site preferences of adult females and the possible effect of global warming.

SEA TURTLE NESTING TRENDS IN THE LAKSHADWEEP ISLANDS OF INDIA

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A one-year study on sea turtles was carried out in the Lakshadweep islands, an archipelago of coral atolls off India's west coast. The islands, comprising 32 square km of land area and 60,000 square km of territorial waters host a regionally significant population of three species of sea turtles – the green turtle, the hawksbill and the olive ridley. Our study focused on setting up an easily replicable monitoring protocol and tagging program in the islands to preliminarily quantify spatial and temporal trends in nesting patterns between the three sympatric species. Onshore assessments were also carried out to determine current status of nesting beaches and existing level of anthropogenic threats to habitat in both inhabited and uninhabited islands. Significant loss of nesting habitat was seen in all inhabited islands as a result of beach armoring and expansion of human habitation up to the high tide line. Monitoring surveys for nesting carried out on Agatti Island revealed variable nesting densities along the island's 15 km long coastline. Over 65–300 nesting attempts were seen in total, with average densities ranging from 40–188 nesting attempts/km of beach length. Index of nesting success was found to be between 0.17–0.29 while nest density ranged from 7.2–25.6 nests/km. Green turtles were more abundant nesters as compared to the other species. Green turtles did not show any specific seasonality in nesting while olive ridleys nested specifically between December and February. However a distinct peak in nesting intensities of green turtles was seen between March and May. Hawksbill nesting was extremely rare and sporadic. Recaptures of tagged green turtles revealed re-nesting intervals of 12 and 14 days (n=2) while nest site fixity was found to range between 0.03–1.4 km (n=7) from the original nest site.

CLUTCH SIZE AND HATCHING SUCCESS IN THE OLIVE RIDLEY SEA TURTLE, *LEPIDOCHELYS OLIVACEA,* AT THE RUSHIKULYA MASS NESTING SITE, INDIA

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Clutch size and hatching success in the olive ridley sea turtle, *Lepidochelys olivacea,* was investigated at the Rushikulya mass nesting site, along the east coast of India, during April–May 2008. A total of 1,941 nests placed along a four km stretch of beach where mass nesting had occurred earlier that year were excavated and examined, soon after the mass emergence of hatchlings. The average clutch size was found to be 122.4 ± 20.1 S.D. (range = 8–179), and with a hatching success (HS) and emergence success (ES) of 84.0% and 80.3% respectively. The nests with clutch size in the range of >100 to 130 eggs were the highest (n = 1,005), while only seven nests had clutch size ≤ 50. HS and ES in the excavated nests were also examined vertically along the beach at three locations: at the high tide line, middle of the beach, and at the vegetation line. As expected, both HS and ES at this site were lowest at the high tide line, while there was no difference between the other two locations. Similarly, a comparison across the mass nesting beach showed that sand spit sections of the beach had higher HS and ES than that of the mainland parts. The mainland parts of the beach had higher numbers of turtle nesting and therefore the low HS appears to be as a result of this. It was also observed that beach sand characteristics may also play a role in the differential hatching success.

WHEN DO THEY STOP? EVALUATING THE LONG-TERM REPRODUCTIVE OUTPUT OF *ERETMOCHELYS IMBRICATA* ON LONG ISLAND, ANTIGUA, W.I.

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While some research has examined the variability in reproductive output between neophytes and remigrants, many important aspects of marine turtle fecundity, such as how fecundity changes as a turtle senesces and how long individuals remain reproductively active, are not well understood. Since its inception in 1987, the Jumby Bay Hawksbill Project (JBHP) has intensively monitored Long Island, Antigua's nesting hawksbill population with saturation tagging protocols. With 23 years of comprehensive nesting data for more than 360 individual hawksbills, including numerous turtles regularly documented over 15 or more years, the JBHP is able to begin to address these questions of reproductive output. Our objective with this investigation is to evaluate within- and among-season changes in fecundity as hawksbills age. We examine a subset of 24 individuals from the JBHP nesting population, with 7 to 11 documented nesting seasons between 1987 and 2009. We assess several measures of individual reproductive output, including remigration intervals, inter-nesting intervals, number of clutches per season, clutch size, and hatch success. We evaluate these reproductive parameters with respect to individual age and nesting experience. Finally, we discuss the ecological and management implications of our findings and make recommendations for future analyses to better understand the relationship between hawksbill senescence and fecundity.

*REPRODUCTIVE PERIODICITY AND ABUNDANCE ESTIMATES OF GREEN TURTLE ADULT MALES AT ATOL DAS ROCAS MARINE BIOLOGICAL RESERVE, NE BRAZIL

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Most sea turtle studies concentrate on nesting biology, mainly because of its importance for their life cycle and logistical ease. Accordingly, little is known on the biology of adult males. Here we investigate reproductive and abundance features of green turtle adult males from the third largest rookery for this species in the South Atlantic, Atol das Rocas Marine Biological Reserve (03°45'–03°56'S; 33°37'–33°56'W). In this rookery, nesting and hatchlings have been monitored since 1990 by the Brazilian Sea Turtle Conservation Program (Projeto TAMAR), and there have also been opportunistic male captures since then. From 2003 to 2007 a specific adult male capture effort was implemented in the beginning of each reproductive season, with expeditions occurring every December–January, for approximately 28 days. Adult males were captured for tagging through free or SCUBA diving, at depths from 0.5–25 m. Each individual was captured only once during an expedition. A POPAN open-population model, chosen based on the Akaike Information Criterion, was applied for estimating males' abundance annually and over the five years, also providing annual return probabilities. There were 181 captures, with 136 individuals tagged and 31 recaptured. Most recaptures occurred in consecutive years (49%) or in one year intervals (44%), suggesting almost annual reproductive activity for green turtle adult males, contrasting with female interbreeding interval of two or three years. Considering previous opportunistic adult male observations, eight individuals were recaptured from 7 to 10 years after first capture, which may be evidence of reproductive site fidelity, similar to females. This fidelity and interbreeding intervals are also demonstrated for green turtle adult males of the Great Barrier Reef. The selected model for abundance estimates considers survivorship and return probabilities varying through time, and constant capture probabilities. Adult male abundance within the five years was estimated at 282 individuals, ranging from 219 to 391 (95% CI). Annual abundance estimates varied, ranging from highest in 2003 with 147 individuals (74 to 220; 95% CI) to lowest in 2006 with 83 individuals (43 to 124). Return probabilities presented wider variation, 37.3% (-2.0 to 76.6%; 95% CI) in 2004, 28.4% (-4.6 to 61.3%) in 2005, 2.7% (-31.0 to 36.4%) in 2006 and 66.7% (26.5 to 106.9%) in 2007. Despite the very low probability obtained for 2006, most likely due to a higher emigration or higher recruitment of new males, these results reinforce a difference in reproductive periodicity between males and females. It is important to point out that a five-year study is relatively short-term and results here discussed should be carefully interpreted. This study represents the first effort of estimating green turtle adult male's abundance and reproductive periodicity through diving mark-recapture data in the South Atlantic and also provides new perspectives on green turtle reproductive biology and importance of studying adult males. Acknowledgements: the authors would like to thank ISTS for a Travel Grant awarded to GOL. We also thank Maurizelia de B. Silva for logistics and help in Rocas Atoll. Zaira Matheus and All Angle Images, Fernando de Noronha, PE, Brazil for technical and logistical support. Projeto TAMAR is affiliated with ICMBio, co-managed by the Fundação Pró-TAMAR, and officially sponsored by PETROBRAS. We dedicate this paper to Fernando Dias Pazeto (in memoriam).

STRUCTURAL DEVELOPMENT OF GONADS DURING EMBRYOGENESIS AT CONSTANT INCUBATION TEMPERATURES

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Freshly laid eggs from green turtles (*Chelonia mydas*) were collected at random from different natural nests at Ras Al-Hadd Reserve, Oman. The eggs were placed in Sayo incubators free from chlorofluorocarbons (CFCs) set at 30 °C. The gauge and the inside temperature showed 0.1 °C difference. The genital ridge appeared undifferentiated before day 20 of incubation with only mitotically divided germ cells. After day 24, there were oogonia with follicular cells around them to form the primary oocytes. Based on light and electron microscopy examinations it appeared that the genital ridge began to differentiate during the thermosensitive period (20–27 days). At the end of

gonadal differentiation period, the ovary showed a well-developed cortical zone. There was an extensive presence of the smooth endoplasmic reticulum in the cortical zone and indicative of steroidogenesis during early development of the ovary. This information is of value in understanding the influence of constant temperature at 30 °C on sex determination.

*ANOTHER DECLINING LOGGERHEAD POPULATION IN THE MEDITERRANEAN: BAY OF CHANIA, GREECE

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One of the "major" loggerhead sea turtle (*Caretta caretta*) nesting sites in Greece is the Bay of Chania at the northern coast of Crete. The nesting beach extends for about 17 km (from Kato Stalos to Kolymbari), of which 13 km are suitable for nesting. The area was discovered in 1990 and has been monitored annually since 1992 by ARCHELON. The nesting beach is divided in several sectors which differentiate strongly in physical features and are in varying stages of coastal development. Human encroachment for housing and tourism has destabilized sand dunes causing considerable beach erosion which today is very apparent. Other reasons for beach erosion are building of harbors and groins, and the removal of sediment from nearby streams. Beach erosion combined with the predominant, during the summer, north winds leads to severe nest inundation. Further, because of tourism and associated activities, nesting turtles are disturbed by humans and hindered by beach furniture, and incubation of eggs can be compromised through trampling by people and/or vehicles on the beach while hatchling survivorship is reduced because of bright artificial lights. Efforts to mitigate, as much as possible, the above problems have been made by in situ fencing of nests to avoid trampling, by relocating them to avoid the negative effect of inundation, and by "shading" to offset light disorientation to emerging hatchlings. The above conservation field measures are coupled with an intense public awareness component as well as liaising with all stakeholders in an effort to achieve long-term protection of the area. The annual number of nests over a 17-year period (1992–2008) ranged from 192 to 38 (nesting density: 14.8–2.9 nests/km). The annual number of nests exhibits a downward trend, reaching an annual decline of about 6%. The decline is attributed to problems both in the terrestrial habitat, despite mitigation measures in place, as well as problems at sea through incidental captures and boat strikes. A similar decline was recently noted in the loggerhead population of Rethymno, another "major" nesting area on the northern coast of Crete. An insight into the future of Chania nesting population is attempted according to different scenarios. The worst-case scenario is that the population has already collapsed and is beyond recovery. The optimistic scenario invests on the success of mitigation measures on land and anticipates an increase of the nesting population in a few years' time.

*REPRODUCTION AND GENETIC STUDY OF HAWKSBILL SEA TURTLES IN IRAN

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Northern parts of the Persian Gulf and Oman sea region host different populations of sea turtles all year long. These populations consist of feeding and breeding individuals. The main feeding group belongs to green turtles which can be seen all year long in different life stages and in both water bodies. On the other hand, hawksbill populations are the dominant breeding groups which mainly nest in different islands during the nesting season, March to May. As the Persian Gulf is a semi-enclosed sea and all the existing countries in the region are in close proximity to each other, the movement or migration of the sea turtle populations has been questionable. In this regard, two hypotheses arise indicating that the different populations of sea turtles either leave the Gulf region or stay in and make movements between the countries within the region. Based on this situation, we started tagging sea turtles in Iran 4 years ago and we tried to cover the main nesting sites. The main nesting sites for hawksbills are a few small and large islands in the Gulf area: nesting of the populations is concentrated in these islands and nowadays there is very little nesting on the mainland. Alongside the tagging program, studying nesting and collecting related information like clutch size and biometry of turtles and eggs (as there have not been any programs before) the idea for genetic works came up. After years, the main basic information on reproduction has been collected. The main objectives

were: genetic identification of Iran's sea turtles, identification of possible different populations in the main nesting sites, finding out the possible links between the sites and comparing the populations of different countries in the region in order to identify any shared populations or habitats as well as finding any clear idea about the migration of turtles in the region. We sequenced 82 samples from four sites in Iran. All samples were collected from within the Persian Gulf. Two rookeries are at Nakhiloo and Ommolkaram, located approximately 20 km apart in the western Persian Gulf. The other two rookeries are at Sheedver and Hendoourabi, located approximately 220 km to the southeast in the eastern Persian Gulf, and they are approximately 40 km apart. We found 11 haplotypes among the 82 samples, most of which have not been previously identified. One haplotype, PG7.1 was found to be the dominant variant at all rookeries, with a frequency of around 50% or more at each. There were five haplotypes (PG7.1 – 7.5) that would not have been recognised as being unique if we had used the previous primers that amplify a shorter segment of DNA, because these haplotypes only showed variation in the new portion of the sequence. This was an important result, because this greater resolution was needed to demonstrate genetic separation between the rookeries. Five of the haplotypes were only observed once and only three haplotypes were observed at >5% frequency across the total sample.

MARINE TURTLES NESTING IN THE ARRECIFES AND CAÑAVERAL SECTORS, IN THE NATURAL NATIONAL PARK TAYRONA (PNNT), SANTA MARTA CARIBBEAN COLOMBIAN (1999–2003)

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To detect changes in turtle nesting activity in the Arrecifes and Cañaveral sectors of the Natural National Park Tayrona (PNNT) we analysed data from the years 1999 to 2003. A database like tool of interpretation of aspects like the activity on beaches, nesting species, characteristic of nests, in situ incubation success, transfer of nests, morphometrics of hatchlings and females, threats, etc. was generated and complemented with records of environmental factors such as oceanic and meteorological conditions and possible threats that influence the process of incubation of eggs. The most important beaches in the area for each one of the species reported were identified and the implemented measures of handling like relocation were considered in these breeding grounds. The studied sectors of the PNNT include 11 beaches appropriate for marine turtle nesting, with a total length of 7,089 m. *Dermochelys coriacea* or "canal" was the first species nesting during the different seasons, arriving from the month of April, followed by *Caretta caretta* or "caguama" which presented its peak between the end of May and the beginning of June. Also, *Eretmochelys imbricata* or "carey" appeared at the end of June and the beginning of July whereas *Chelonia mydas* was the last one having a peak, particularly in the months of July and September. The maximum nesting activity of marine turtles during the different studied seasons agreed with the well-known climatic time like "Veranillo of San Juan" (June–July). Incubation durations for *C. caretta* in the season of 1999 were 48.5 days and in 2002 were 51 days. During 2003, *E. imbricata* nests incubated for 50 days and *D. coriacea* for 61.3 days. In general with the information available for historical analysis, it was not managed to determine the pattern of preference of arrival for the different species as the inaccuracy of data prevented a conclusive analysis. Nevertheless we demonstrated some tendencies that should be followed. The ability to know the real situation for these species from accumulated data recording over several years was due to standardized collection of initial data and it is essential to continue this process in order to update the data which will be evaluated with the Geographic Information Systems (GIS) used by the PNNT.

*FALL AND RISE OF THE NESTING GREEN TURTLE POPULATION AT ALDABRA ATOLL: POSITIVE RESPONSE TO FOUR DECADES OF PROTECTION (1968–2008)

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Aldabra atoll, Seychelles, in the western Indian Ocean is a UNESCO World Heritage Site managed by the Seychelles Islands Foundation, where all wildlife and ecosystems have been protected since 1968. Aldabra provides an unusual opportunity to document both decline and recovery of an over-exploited green turtle nesting population. This is possible, thanks to: a) historic records from the 16th and 17th centuries; b) government statistics recording national calipee exports from 1906 to 1968; c) baseline data collected during three separate surveys of the nesting population conducted in the late 1960s and early 1970s, just before and after effective long-term protection was implemented for Aldabra turtles (in 1968); d) a long term, ongoing monitoring programme conducted during >28 years (1981–2008) that implements a standardised protocol involving regular track counts at a series of index beaches which together host more than 50% of annual nesting activity; and e) a nesting turtle tagging programme underway since 1981. Analysis of these data indicate that the population reached a low of ~500 females nesting annually in the late 1960s and has increased to the current estimate of some 4,000 females nesting annually in recent years. During the past four decades the population has increased exponentially at an average annual rate of >5%. At its current rate of increase, the population is likely to double within the next 15 years. Potential carrying capacity of the Aldabra nesting beaches is discussed in the context of available nesting habitat and historic records from the 17th century.

STATUS AND TRENDS OF NESTING TURTLES AT D'ARROS ISLAND / ST. JOSEPH ATOLL, AMIRANTES GROUP, REPUBLIC OF SEYCHELLES

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D'Arros Island and St. Joseph atoll comprise part of the low lying Amirantes Group in the Seychelles. Since at least 1880, they were managed as copra plantations, and over the next century nesting hawksbills (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) were intensely exploited for shell and meat, respectively. When the current management took over D'Arros in 1975, it tried to promote turtle protection, but could not effectively enforce these efforts until national legislation protecting all turtles was enacted in 1994. Some poaching continued, however, until 2004 with construction of the D'Arros Research Centre, and initiation of an intensive turtle monitoring programme implemented on a daily basis by members of the local Seychellois community based on D'Arros. Our study presents the results of 28 years (from 1982 to 2009) of rapid surveys and long term monitoring of sea turtles nesting at D'Arros Island and adjacent uninhabited St. Joseph Atoll. We found evidence of population increase during that period and present current estimates of annual numbers of nesting females. For the first time, seasonal patterns of nesting activity for green turtles and hawksbills in the Amirantes group are described and compared with those elsewhere in the region – especially at Aldabra atoll, and in the Granitic Seychelles. We conclude that the turtle populations of D'Arros and St. Joseph are so remarkable as to warrant the status of "Sanctuary for Turtles and their Habitats."

WHY DO FEMALE LOGGERHEADS MATE MULTIPLE TIMES?

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Movement and sex-biased dispersal patterns can affect the availability of mates, and thus the opportunity for multiple matings resulting in multiple paternity. In the presence of potential mates, the choice to mate once or multiple times can affect individual reproductive success as well as the genetic diversity of the entire population. Recent studies on the mating systems of marine turtles have revealed a great deal of variation in the frequency of multiple paternity within and among species. To test the hypothesis of a correlation between the frequency of multiple paternity and female abundance for loggerhead turtles (*Caretta caretta*), we sampled clutches, and when possible their mothers, from two genetically distinct populations with different estimated female abundances: Quintana Roo, Mexico (QR) and northwestern Florida (NWFL). Samples were genotyped at 10 microsatellite loci. A significantly greater proportion of sampled clutches in QR exhibited multiple paternity (24/40) compared to NWFL (2/22) (X^2 $p<0.05$). While the results for these two populations alone support the hypothesis of an increasing frequency of multiple paternity with female abundance, combined with previous studies of multiple paternity in loggerheads, the relationship is not supported. We then tested the correlation of multiple paternity with nest density, as a proxy for density of breeding turtles. Although not strong, there was a positive correlation (published results from two other populations were included in this correlation). To test if sex ratio skew is correlated with multiple paternity, we used the paternity analysis to estimate the total number of males that mated with the females to derive at operational sex ratios for each population (QR–1.7 males:1 female; NWFL–1.2 males:1 female). While these sex ratios are not quite significantly different (X^2 $p=.09$), a larger sample size may show a stronger correlation between a more male-biased sex ratio and multiple paternity. To test the hypothesis that females mate multiple times in order to gain reproductive fitness benefits, we measured various estimators of reproductive fitness. Of these, only the total number of clutches laid over the course of the season tended to be higher for females with multiple paternity (T-test $p=0.06$). Laying additional clutches every season can greatly increase a female's reproductive output over the course of her lifespan, thus justifying the potentially high cost of mating. Consecutive clutches (six, four, and four) laid by three individual females were tracked over the course of the nesting season. For two families (n=117 and n=77), two males each sired equal proportions of offspring (X^2 $p<0.05$), with a third and fourth male each siring less than 4%. The third family (n=82) had one dominant male siring 82%, with the second and third males siring 12% and 5%, respectively. The presence of all paternal alleles in the first two clutches suggests females mate prior to nesting and that males leave the breeding area. Alternatively, females may no longer be receptive once they begin nesting. Additionally, this pattern of paternity supports the idea that females may mate early during migration, allowing for male-mediated gene flow between genetically differentiated matrilineages.

*WESTERN NORTH ATLANTIC LOGGERHEADS: LONG TERM SEX RATIO TRAJECTORIES

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For more than 25 years we have been accumulating juvenile loggerhead sex ratios along the east coast of the United States. Using a testosterone based sex predicting technique followed by selected validations with direct visual laparoscopic verification, foraging ground population sex ratios in four distinct areas were determined. Sex ratios for northern sub-populations appear to be remaining stable at about 70% female over the past 15 years while a southern

sub-population sex ratio is trending toward more female domination, with 58% female in the late 90s and 84% females in the late 2000s. The cause of the long term drift in the southern ratio may be related to global warming, rainfall patterns on the nesting beaches or to shifts in the specific nesting beaches contributing to the foraging ground population. Regardless of the explanation, the southern sub-population seems to be undergoing an important demographic change related to sex allocation. An important additional question is how many males are enough in a given population?

THE NESTING CHARACTERISTICS OF SEA TURTLES ON SAMANDAĞ BEACH, TURKEY

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Samandağ Beach is one of the three most important nesting beaches in the Eastern Mediterranean for green turtles (*Chelonia mydas*). This beach is also nesting habitat for loggerheads (*Caretta Caretta*). Variation in nest numbers recorded from nine years of monitoring are summarised in this study. The human impact on the nesting activity is argued and some solutions are suggested. A remarkable increase has been observed in number of green turtle nests in the last three years. In terms of nest numbers, 2009 was the best year.

NESTING BEACH ENVIRONMENTS AND REPRODUCTIVE STATUS OF OLIVE RIDLEY SEA TURTLES (*LEPIDOCHELYS OLIVACEA*) IN NORTH ANDHRA COAST OF BAY OF BENGAL, INDIA

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The north coast of Andhra Pradesh is an important sporadic nesting habitat for olive ridley sea turtles (*Lepidochelys olivacea*) of diverse beach environments from riverine sand spits, high elevated beaches and occurrence of rocky shores of calcareous origin. Breeding populations of olive ridleys migrating from the Indian Ocean to Orissa mass nesting beaches through the coastal waters of Andhra Pradesh utilize the North Andhra Coast for their sporadic nesting activity. Analysis of the nesting beach environments of olive ridleys in relation to beach geomorphology (beach profiles, grain sizes and sand compactness) and geographical details (location of nesting beaches and vegetation composition) is an important study for effective conservation and management of olive ridley sea turtle nesting habitats. Nesting beach environments help determine the nesting status (frequency of nesting and density of nests) and reproductive success (hatching of eggs and survival rate of hatchlings) of sea turtles. Nesting density (>10 nests/km) was highest in fine sand beaches of larger river mouths with sorting grain sizes from 0.1560 to 0.2234 mm. Lowest nest densities were observed in high elevated beaches (<5 nests/km) of medium sands of grain sizes between 0.1792 and 0.1948 mm, followed by isolated rocky beaches (±2 nests/km) in coarse sands of grain sizes from 0.5117 to 0.6472 mm. Hatching success also varied from riverine beaches of fine sands (32.0%) to the mainland beaches of medium sands (22.0%). The lowest hatching success rates (5.0%) were recorded at rocky beaches due to calcareous origin and less compactness. The hatchling mortality rates were found to be highest in fringed beaches adjacent to river mouths due to heavy predation, high compactness in sand particles and frequent inundation. As part a conservation measure, vulnerable nests were relocated to nearby suitable nesting beaches and protected until the eggs hatched and the hatchlings entered the marine waters.

SPATIAL DISTRIBUTION OF MARINE TURTLE NESTING ACTIVITY IN THE PILBARA REGION OF WESTERN AUSTRALIA 2008–2009: COMBINING SURVEY TECHNIQUES TO DESCRIBE REMOTE HABITATS

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Little is known about the biology and ecology of marine turtles in the Pilbara region of Western Australia. The Pilbara is considered remote and access to marine turtle nesting areas is limited. The Pilbara coastline supports multiple oil and gas extraction and processing facilities which overlap with marine turtle habitat. The expansion of industrial activity in the Pilbara has facilitated greater access to, and consequently awareness and management of, marine turtle populations in the region. During the 2008/2009 marine turtle reproductive season surveys documented species-specific track counts, reproductive output and hatchling sea-finding behaviour at previously un-assessed coastal mainland and island sites within the Pilbara region. Here we describe nesting activity and distribution of marine turtles at 51 mainland and coastal island sites within the Pilbara region as detected via ground and aerial surveys and provide for the first time, a broad spatial overview of marine turtle distribution and nesting activity. Flatback turtle nesting activity was widespread across both coastal and mainland survey sites. Considerable rookeries exist at Mundabullangana and Barrow Island and cumulatively, other sites documented within the region may represent significant rookeries for this species. Green turtle nesting activity was less widespread than flatback activity. Flatback turtle nesting activity was documented at most surveyed mainland and coastal island sites where suitable nesting habitat was available with tracks recorded at 26 of the 28 island sites and 18 of the 23 mainland sites. Evidence of green turtle nesting was only recorded at 14 of the 28 island sites and 3 of the 23 mainland sites. Published data regarding green turtle hatch success in Australia are scarce. Mean hatch success was 92.3 ± 5.7 % (range: 77.9–100.0, n = 15) and mean clutch size was 92.3 ± 5.7 eggs (range: 46–114, n = 15). No artificial light exists at any survey sites and therefore quantitative record was made of natural hatchling sea finding behaviour for both species.

*THE ECOLOGY OF FLATBACK SEA TURTLE (*NATATOR DEPRESSUS*) NESTS AT PEAK ISLAND, AUSTRALIA

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Flatback turtles (*Natator depressus*) are the only species of sea turtle with a restricted distribution. They are endemic to the Australian continental shelf, predominantly nesting on mainland beaches and continental islands. Recent research has focused on a small continental island, Peak Island, 13 km from the central Queensland mainland. The average clutch size is 50 eggs of 52.1 mm diameter. The proportionally larger eggs of flatback turtles was originally thought to allow the production of a larger hatchling, to minimise the mortality rate of neonates remaining on the predator-rich continental shelf. However, a larger egg size also allows flatback turtles to withstand high mean nest temperatures that may fluctuate greatly and low substrate water content when compared to conditions at nesting beaches utilised by other sea turtle species. Despite an adverse thermal and hydric microclimate the hatch and emergence success of flatback turtle nests is consistently comparable to species and rookeries in eastern Australia. Fungal infection and dipteran invasion of nests is comparatively lower because of the challenging environment. The tolerance of the flatback turtle egg to extreme substrate conditions may enable survival of nests laid at Peak Island under expected climatic changes such as higher temperatures, if current conditions are not already approaching the upper tolerance limits. The greatest threat may come from more frequent storm events and rising sea levels threatening the beach, and local climate change damaging the feeding grounds utilised by females between nesting seasons.

*CONSERVATION GENETICS OF THE FLATBACK TURTLE (*NATATOR DEPRESSUS*): A COMPARATIVE ANALYSIS USING MICROSATELLITES AND MTDNA

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The flatback turtle (*Natator depressus*) is endemic to the continental waters bordering northern Australia and New Guinea, and nests exclusively on the northern Australian coast and adjacent inshore islands. Despite the relative remoteness of this region, industrial and urban developments and feral animals are beginning to impinge on their habitat, raising concerns over potential impacts. This has led to the classification of the species as vulnerable by Australian Federal Government and some State Governments. As a consequence to these threats, greater information on the population dynamics of the species is needed for their effective conservation. Population genetic methods have been applied extensively to sea turtle populations around the world and have provided diverse information of relevance to the conservation of the seven species. This includes providing evidence for key theories on sea turtle behaviour, including natal homing, juvenile migrations and sex biased gene flow. Initial population genetic research on the flatback turtle has indicated moderate structure and genetic isolation by distance among several nesting populations across Australia, and has defined four management units using the available data. However, a recent study on the mating system of the species using new genetic markers has identified additional segregation among three rookeries that were previously grouped as one unit, highlighting a need to increase sampling efforts at new and existing locations and apply new microsatellite markers with greater variability to better determine the boundaries of management units. The present research aimed to expand on these initial investigations and provide comprehensive estimates of genetic population structure over the species nesting range. Primary objectives of the study were to identify the level of differentiation among populations, the degree of connectivity among populations, assess sex biased gene flow, determine whether a genetic bottleneck has occurred in the past and identify relevant management units. At least 30 individuals were sampled from each of eleven nesting populations spanning the species' range, including four from both Western Australia and Queensland and three from the Northern Territory. Ten to twelve cross-specific nuclear microsatellite markers, of which 5 to 6 are new, are being used in conjunction with sequencing of the mtDNA control region. Results of these analyses were used in conjunction with mark-recapture and satellite tracking data to identify relevant management units across the species' range.

*LEATHERBACK NESTING AT THE OSTIONAL OLIVE RIDLEY ARRIBADA BEACH, GUANACASTE, COSTA RICA

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A study was undertaken at Playa Ostional (9°59'38N, 85°42'05W), from November 2004 to May 2009, to quantify sand temperatures and to determine the hatching success of leatherback nests laid on this olive ridley arribada nesting beach. A total of 76 leatherback nests were excavated, of which 34 were left in situ, and 42 were relocated to a hatchery. Mean hatching success in the hatchery was 25.98%. For in situ nests, mean hatching success differed among the three sections of the beach: 0% (n=7, Punta Rayo, north end), 0% (n=20, middle section), and 19.51%

(n=7, Nosara, south end). Mean temperature in nests at the hatchery was 30.90 °C (n=6). Mean temperature at the north end was 34.94 °C (Punta Rayo, n=5), in the middle section was 35.47 °C (n=7) and at the south end was 32.37 °C (Nosara, n=1). Hatchery nests were cooler than those located in any other sector of Ostional beach, and the warmer nests were found in the middle section of the beach where the major olive ridley arribada occurs. Dead hatchlings with early embryonic development found inside the eggs were only observed in Punta Rayo and Nosara sector, both located in the south and north ends of Ostional beach, away from the main area of olive ridley arribada. Eastern Pacific leatherback populations have decreased exponentially over the last two decades, and potential recovery will depend on integrated efforts, which for those working on the nesting beaches, need to include a deeper analysis of the biotic and non-biotic factors determining the hatching success so that hatchling output is maximized and appropriate management plans are developed.

GENETIC VARIABILITY IN CUBAN GREEN TURTLE NESTING ROOKERIES AND MTDNA GENETIC SEQUENCES SIZE

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A genetic study involving a 742 bp partial sequence of the mtDNA control region was performed for nesting female green turtles in the western rookeries of the Cuban archipelago. Four rookeries were sampled including nine beaches in total. This region was defined using primers designed by Abreu (unpublished). It was possible to identify 14 polymorphic sites with 11 transitions, one transversion and 2 insertions/deletions (indel). Six of the already known haplotypes were divided into two genetic variants because of the changes observed in site 693, which involve an indel of A, resulting in the identification of 17 haplotypes. With the exception of the haplotype CM-A1, the rest of the divided haplotypes had a variant more abundant than the other. In general, there was a close relatedness between the haplotypes. The difference between most of the haplotypes was of only one change and of the transitional type, making it possible to consider the origin of most of them as local. Also, the haplotype frequency distribution generates longitudinal gradients. Haplotypes CM-A3.1, CM-A1.2, CM-A13.1 and CM-A48.2 increase their frequency from the West to the East, and the opposite occurs with CM-A27. The CM-A48 haplotype, the best represented Cuban endemic, is distributed in similar frequencies inside Guanahacabibes, but is not found in the other rookeries. As a result, Cuban haplotype diversity increases, although the nucleotide diversity is lower because of the relationship between most of the haplotypes.

NEW STATISTICAL MODEL TO ELUCIDATE THE TOTAL CLUTCH FREQUENCY OF MARINE TURTLES

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According to the IUCN Red List, leatherback turtles, *Dermochelys coriacea*, are classified in the most threatened category: “critically endangered (CR)”. It is true that anthropic threats and responses to climatic changes have an important impact on these populations’ dynamic. Distinguishing between these two factors is necessary in order to settle efficient conservation actions. The nest number per female is used as an index of reproductive effort for a female, but its estimation could be biased because monitoring patrols could miss some nesting events. Several methods were developed in order to enhance knowledge of reproductive strategies and their mechanisms. In French Guiana, previous studies proposed that heterogeneity of reproductive strategies among females could explain the observed data. Therefore, a model of nesting strategies by females may be a useful tool to evaluate various propositions. With this, the analysis of monitoring years could bring more accuracy to the trend of this species.

Several models were built and tested against data. After comparison, the selected model shows heterogeneity in the probability to nest on a given beach. We found that some females appear to be erratic and others faithful to their nesting beach. Moreover, it appears that a reduction of the capture effort in the middle of the nesting season prevents conclusions on the individual behavior.

SATURATION TAGGING PROGRAM OF NESTING HAWKSBILL TURTLES (*ERETMOCHELYS IMBRICATA*) IN NORTHEASTERN BRAZIL

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The southeast coastline of the state of Rio Grande do Norte Brazil (6°13'40"S, 35°03'05"W) has been protected by Projeto Tamar/ICMBio, the Brazilian sea turtle program, since 2000. Tagging of nesting hawksbill turtles started in 2004/2005 with random effort. Saturation tagging effort (STE) started on the 10th December and ceased after 17 days with no nesting activity, and were resumed in the nesting seasons of 2006/2007, 2007/2008 and 2008/2009. The beach area of 4 km total was monitored every 40 minutes, starting at 7 pm and ending at 4:30 am. Furthermore, morning patrols were conducted daily starting on the 15th September until the emergence of the last nest. The nesting season lasts from October to May; however the period between January and March concentrates 84% of nesting activity. Average clutch size was 138 ± 31.6 eggs (range 6–259 eggs; n = 696). In situ nests presented average emergence success of 57.5% (n = 623) and average incubation period of 57.6 ± 3.77 days (range 50–73 days; n = 386). During the three nesting seasons (2006/2007, 2007/2008 and 2008/2009), 48, 31 and 53 nesting females were identified and the number of nests was 113, 84 and 133. In the first season 5 remigrants were found (tagged during the past random effort - PRE), followed by 7 remigrants in the second (still from PRE) and finally by 24 remigrants in the last (22 remigrants from the first STE – 2006/2007 cohort, plus two remigrants from PRE). Thirty-three females returned within two years and three within three years with average remigration interval results in 729 ± 105 days (range 654–1076 days; n = 36). As the lower remigration interval was two years, the 2008/2009 nesting season represents the zero point for the comparison between the cohorts. Out of 48 females (2006/2007 cohort), 21 returned to nest within 4 km in extension and one was found during a random effort approximately 45 km Northward, at Barreira do Inferno beach, where it nested. The curved carapace length was 0.92 ± 0.04 m (range 0.83–1.025 m, n = 89). Average first post-oviposition mass was 79.6 ± 11.3 kg (range 56.2–105.7 kg; n = 72). Individuals laid one to six clutches, the average was 2.48 ± 1.65 clutches (n = 132) and 47% of females was seen only once within the nesting season. Average internesting interval was 14.8 ± 1.4 days (range 12–18 days, n = 122), excluding from the analysis all intervals >23 days, which were attributed to unobserved nesting events. Internesting intervals greater than 23 days were observed 58 times which could indicate that individuals are also using adjacent areas. Despite the possible use of adjacent areas by nesting females, the internesting interval pattern can work as correction factor to estimate clutches per individual. Even under this assumption, a concomitant effort to identify nesting females in the adjacent beaches may contribute to more precise estimate number of clutches per individual.

*RECONSTRUCTING MALE GENOTYPES AND EXPLORING MULTIPLE PATERNITY FOR LEATHERBACKS NESTING AT SANDY POINT NATIONAL WILDLIFE REFUGE

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The prevalence of multiple paternity varies widely in the animal kingdom, from low levels of multiple paternity, to several males contributing to offspring. Assessing paternity is more complicated for species that may store sperm for days to years. For marine turtles, which do store sperm, multiple paternity appears to vary by species, with one to two fathers being most common. Since relatively little is known about male leatherback turtles, genetic techniques may give us insights into the mating system while informing us about leatherback life history. Females are known to return to their natal beach for breeding and nesting, and it appears that males may return as well. The purpose of this study was to determine the level of multiple paternity at a well-studied leatherback rookery at Sandy Point National Wildlife Refuge (St. Croix, USVI), and then to reconstruct male genotypes (fingerprints) to examine whether these

males exhibit natal homing. During the course of a genetic mass-tagging project for hatchlings (sampling over 6,900 hatchlings), we chose a subset of clutches for examining multiple paternity. We sampled nests laid within a 6-week period that had been laid by 12 individual females. We chose females that had been observed nesting at St. Croix for varying periods of time. Five females were first- or second-time nesters, and seven had been nesting for at least 5 years, and up to 19 years. We sampled all live hatchlings (n = 1,064) as they emerged from 36 nests. Using a 2 mm biopsy punch, we took a skin snip from the trailing edge of the front flipper. Hemostatic agents were applied to the flipper to prevent bleeding and hatchlings were held for observation before release. Samples were stored individually in 96-well sample plates in a saturated salt solution. Total genomic DNA was extracted using standard protocols. We used 7 microsatellite markers to genotype (fingerprint) the hatchling samples. These markers are polymorphic (many alleles possible per locus) and contain high levels of diversity for the St. Croix population. The markers also contain alleles unique to St. Croix, which allowed us to be confident in assessing male genotypic origins. Multiple paternity was detected by assessing the number of alleles at each locus. Since the maternal genotype was known, those alleles were accounted for in the genotypes of the hatchlings. If there remained 3 or more alleles at 2 or more loci, then we concluded that multiple males had contributed to the clutch. We then reconstructed male genotypes and compared the allele frequencies with the frequencies for the larger St. Croix population. We found some evidence of multiple paternity both within and across clutches from individual females. The most common paternity type was single. The male genotypes contained alleles at frequencies consistent with the St. Croix population, thus suggesting that these males are exhibiting natal homing. This is the most comprehensive study on multiple paternity for any marine turtle species, assessing females of different reproductive ages and examining paternity within clutches and across the nesting season.

NEST SURVEY OF OLIVE RIDLEY TURTLES, *LEPIDOCHELYS OLIVACEA,* ALONG BEACHES OF SRIHARIKOTA ISLAND, ANDHRA PRADESH, INDIA

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A 10 km long beach was surveyed during the 2003 and 2006 breeding seasons (January–March) to obtain basic data on the sea turtles nesting in Sriharikota and identify the conservation issues facing them. Sriharikota is a spindle shaped island (181 km^2) situated in Nellore and Tiruvallur districts of Andhra Pradesh and Tamil Nadu respectively. It is bounded on the east by the Bay of Bengal and on the north, south and west by the waters of Pulicat Lake. The island comprises of low ridges of sand, marine and aeolian in origin, rising 4.5–6 m and sloping from west to east. The water table is ca. 2 to 5 m. Sriharikota has been connected by road to Sullurpet (18 km) on the mainland since 1970. In 2003 and 2006 respectively, 10 and 17 surveys were conducted in this stretch, starting from the northern tip of the island. Totals of 27 nests and 60 nests of the olive ridley were recorded during the 2003 and 2006 breeding seasons. Of these, only two nests were found intact each year. The rest were preyed upon either by jackals or wild boar (52% in 2003 and 41% in 2006) or collected by people (75% in 2003 and 22% in 2006). Other than nests, complete olive ridley carapaces, 22 in 2003 and 36 in 2006, were located.

*THERE ARE STILL TURTLES NESTING IN THE DOMINICAN REPUBLIC

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Sea turtle nesting populations in the Caribbean have experienced massive reductions due to human exploitation. Although many rookeries are well studied, there are gaps in the regional monitoring efforts and the Dominican Republic (DR) represents one of these. Here we present the first detailed assessment on the status of marine turtle nesting in DR for more than 25 years based on systematic monitoring carried out over four nesting seasons (2006–2009). Nesting populations of regional importance of two species, the hawksbill (*Eretmochelys imbricata*) and the leatherback (*Dermochelys coriacea*), were described. A third species for which breeding was previously considered extirpated, the green sea turtle (*Chelonia mydas*), has been confirmed as present, although in very low numbers. Two main nesting sites have been identified: the Jaragua National Park (Southwest DR) mainly for leatherbacks (127 ± 88 nests/season, range: 18–218), and Saona Island (del Este National Park, Southeast DR) mainly for hawksbills (ca. 100 nests/season). Data from extensive surveys and interviews over the northern and eastern coasts of the country revealed sporadic nesting of leatherbacks and hawksbills throughout the DR coast but in very low numbers (estimated at 25 nests per annum, 1–3 nests/beach/year). mtDNA rookery samples were analysed to determine the links between DR nesting turtles with other nesting populations of the Caribbean. A total of 42 DR leatherback samples were analysed finding two haplotypes, the A haplotype, a common haplotype for Atlantic populations, and the C haplotype. Links were found with populations from Costa Rica and Suriname, and significant differences were found with few closer populations (Trinidad and St. Croix in the U.S. Virgin Islands). A total of five haplotypes were found in 48 DR hawksbill samples, haplotypes A, F, L, Q and N although the latter was present in Saona but not in Jaragua NP suggesting linkage with the nearby Mona Island rookery, Puerto Rico. A great degree of differentiation was found between DR hawksbill nesting rookeries and other nesting populations in other Caribbean countries. Although there are more nesting turtles in DR than generally expected the nesting aggregations are still under threat, principally from illegal egg take and captures by fisheries, and despite recent actions taken by DR government, the illegal but extended trade of hawksbill tortoiseshell products.

*AGE AND GROWTH STUDY OF THE SOUTH AFRICAN LOGGERHEAD TURTLE (*CARETTA CARETTA*)

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Growth curves and notching are common techniques in order to determine age and growth within a sea turtle population. In South Africa notching is applied since 1971/72 as part of a well developed sea turtle monitoring program. Until today a significant number of notched loggerhead (*Caretta caretta*) females (n=74) have returned and were measured. As double-notching (n=17) is considered to be more precise than single notches, age and size at sexual maturity were calculated at an average of 18 years (SE±1.1) and an average SCLmin of 830.6 mm (SE±10.45). To verify these results a logistic growth curve was established where different data sets (captivity/wild; single-/double-notched) were included. The growth curve (n=257) predicted an average age of 16 years with an average SCLmin size of 833.71 mm at sexual maturity. As the smallest nesting loggerhead female in South Africa had a SCLmin of 720 mm, we can say that the females from the South African loggerhead turtle population mature at an average age of 16–18 years, within a size range of 720–935 mm.

*PHYLOGEOGRAPHY OF THE HAWKSBILL TURTLE (*ERETMOCHELYS IMBRICATA*) FROM THE INDO-PACIFIC REGION

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We analyzed the genetic structure of rookeries in 13 regions of the endangered hawksbill turtle (*Eretmochelys imbricata*) in the Indo-Pacific region using mitochondrial DNA control region sequences. Tissue and blood samples were collected from 416 nesting females at rookeries in the Solomon Islands (n = 41); Milman Island, Qld (n = 51); Northeast Arnhem Land, NT (n = 38); Rosemary Island, WA (n = 16); Varanus Island, WA (n = 30); Peninsular Malaysia (n = 23); Malaysia Turtle Islands (Sabah, n = 25); Chagos (n = 21); Republic of Seychelles at Amirantes (n = 20), Platte Island (n = 19) and the Granitics (n = 37); Saudi Arabia (n = 13) and Iran (n = 82). A 739 bp fragment of the control region was amplified using the H950/LTEi9 primers (Abreu-Grobois *et al.* 2006) to reveal 45 different haplotypes. The most common haplotype (EIIP-33) was observed in 84 individuals. Comparisons with shorter control region sequences (381 bp) revealed that one haplotype (EiATL) found in nesting areas from the Chagos and Seychelles was previously observed (Lara-Ruiz *et al.*, unpubl data) in an Atlantic feeding ground in Brazil. The mean number of haplotypes per rookery was 5.2, ranging from 2.0 for the Peninsular Malaysia to 11.0 for Iran. An analysis of molecular variance (AMOVA) showed high levels of differentiation between the Atlantic and the Indo-Pacific regions. Pairwise FST tests showed no divergence ($p>0.15$) between some pairs of populations from close geographic areas (Milman Island vs. Northeast Arnhem Land; Varanus vs. Rosemary Islands, Chagos vs. Seychelles, Saudi Arabia vs Iran). Samples from Peninsular Malaysia came from both the east and west coasts, but there were not enough samples to test whether these locations differed. Our data suggest that the hawksbill turtle rookeries from the 13 Indo-Pacific rookeries studied herein belong to, at least, seven separate genetic populations and should be considered as independent Management Units (MU's) as follows: Western Australia (Varanus and Rosemary Islands), Northern Australia (Milman Island and Northeast Arnhem Land), Solomon Islands, Malaysia (Sabah) Turtle Islands, Peninsular Malaysia, South Western and Central Indian Ocean (Chagos and Seychelles), and North Western Indian Ocean (Saudi Arabia and Iran). This work is aimed to provide relevant data towards the effective conservation management of hawksbill turtles populations throughout the Indo-Pacific region. We thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes), Fundação de Amparo a Pesquisa de Minas Gerais (Fapemig), and U.S. Fish and Wildlife Service for the grants.

CORRELATION OF LOGGERHEAD TURTLE NESTING NUMBERS IN ZAKYNTHOS WITH THE SEA SURFACE TEMPERATURE AT THIS POPULATION'S FEEDING GROUNDS

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Sea turtles spend an important part of their life time in foraging grounds. Here they reach the threshold body condition (energetic reserve) that allows them to migrate to areas where they reproduce. Reaching this body condition can be influenced by environmental parameters in the foraging grounds, determining if an individual breeds in a given year and leading to variation in nesting numbers and probably remigration intervals. Sea Surface Temperature (SST) has been shown to be an environmental parameter affecting many life cycle stages of sea turtles. For Pacific loggerheads, it was shown that the number of turtles nesting in a given year is correlated with SST in the

foraging grounds for this population. This relationship in an area such as the Mediterranean could have serious implications to the populations nesting there in a case of global warming, as their capacity to displace their foraging grounds within the basin is limited. Therefore, the objective addressed in this study was to explore potential correlations between the population dynamics of loggerheads nesting in Zakynthos and the SST in the main regions where these turtles are known to feed (Adriatic Sea and Gulf of Gabès). In order to explore this correlation, a Generalized Additive Modeling Approach was used. Nesting time series for a 25-year period was obtained for the population nesting in Zakynthos. In addition, monthly Pathfinder v5 (4.4 km resolution) SST data products from the Gulf of Gabès and the Adriatic Sea were downloaded using the Integrated Data Viewer (IDV) software, which was also used to average these monthly images into yearly temperatures for both places. It was found that SST in both places oscillates from one year to the other, but a general trend to higher temperatures was observed along the 25 years. Moreover, in addition to the study done for Pacific loggerheads, it was shown that the number of nests is correlated with the SST in the year prior to the nesting season (although in this case the correlation is positive) in both the Adriatic (r^2=0.30; F=6.032, df=1, $p<0.05$) and the Gulf of Gabès (r^2=0.36; F=4.05, df=2.19, $p<0.05$). A tangible explanation for this correlation is that warmer temperatures, especially in the colder months, might allow loggerheads feeding in these areas to spend more time actually eating, and less time resting on the bottom (behavior which occurs when temperatures are very low), allowing them to acquire more energy reserves (thus increasing nesting numbers in the next season).

BREEDING BIOLOGY OF TWO MAJOR FLATBACK TURTLE (*NATATOR DEPRESSUS*) NESTING POPULATIONS: BARROW ISLAND AND MUNDABULLANGANA, PILBARA REGION, WESTERN AUSTRALIA

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Barrow Island and Mundabullangana (Pilbara region, Western Australia), support substantial flatback turtle (*Natator depressus*) populations and have been the subject of a major tagging program over the last four years. A total of 3,064 turtles were first-time tagged at Barrow Island and 818 turtles at Mundabullangana since the start of the program in 2005/06. The mean remigration interval was 1.7 ± 1.5 years and 3.1 ± 2.4 years for the Barrow Island and Mundabullangana populations, respectively. The mean internesting interval was 14.3 ± 2.4 days for Barrow Island turtles and 11.9 ± 2.1 days for Mundabullangana turtles. Barrow Island females (90.1 ± 2.7 cm) were larger than Mundabullangana females (88.8 ± 2.7 cm). Clutch sizes were similar in both populations with a mean of 46.8 ± 10.6 eggs for nests laid at Barrow Island and 47.0 ± 9.7 eggs for nests laid at Mundabullangana. The two populations from the Western Australia genetic unit are similar in size to flatback populations from the Gulf of Carpentaria stock, significantly larger than populations from the Northern Territory stock, but significantly smaller than the eastern Australia populations ($p < 0.0001$). Barrow Island and Mundabullangana clutch sizes are similar to the other population from the Western Australia stock but significantly different from all populations in other stocks ($p < 0.0001$). This paper provides important baseline data for future monitoring of these two major nesting populations and potential impacts from future development in the Pilbara region of Western Australia.

FITNESS CONSEQUENCES OF MULTIPLE PATERNITY IN A MEDITERRANEAN GREEN TURTLE POPULATION

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Use of molecular techniques to assign parentage has revealed that multiple mating by females is widespread across all marine turtle species studied to date. The fitness consequences of multiple paternity in marine turtles are unknown, although they may have far reaching implications for effective population size, genetic diversity of populations, and potential impacts of biased operational sex ratios under future climate change scenarios. It is widely assumed that polyandry should render fitness benefits but empirical support for this hypothesis in marine turtles is absent. We present results of the first comprehensive study of multiple paternity and its influence on possible fitness parameters in a nesting population of green turtles (*Chelonia mydas*) in the Mediterranean. Using 14 microsatellite loci we examined paternity in clutches of all females (n=20) that nested at Alagadi beach, northern

Cyprus in 2008. Using a long-term database of nesting information from these marked females, we investigate relationships between multiple paternity and parameters of clutch success, maternal traits, and measures of offspring fitness. By analysing multiple clutches of a subset of females we also determine individual variation in re-mating behaviour and male contributions across the nesting season. Our study reveals patterns of paternity that have implications for understanding the dynamics of sexual selection in this species, as well as contributing to the effective management of this population. We are grateful for funding from the Natural Environment Research Council (NERC), the NERC Biomolecular Analysis Facility and the Society for the Protection of Turtles.

RESEARCH IN SOCIAL SCIENCE

*SHARED SPACES: FIRST AND SECOND-ORDER CONFLICT IN THE USE OF SEAGRASS HABITATS BY GREEN TURTLES AND FISHER COMMUNITIES IN THE AGATTI LAGOON

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Conflict between humans and wild species is rapidly becoming one of the most important hurdles to effective species conservation. Managing this conflict requires a clear understanding of its mechanisms, whether they be ecological, socio-economic or perceptual. We present an interview-based case study from the Agatti lagoon, Lakshadweep Islands, Indian Ocean, where there is a significant conflict between local fishing communities and a resident green turtle population over shared ecosystem resources. We used semi-structured interviews with 65 fishers to determine perceptions and attitudes towards green turtles. Responses were subjected to a thematic analysis which was qualified across all interviews. A vast majority of interviewed fishers (74% of fishers interviewed) ascribe a decadal decline in their fish catch from the lagoon to a commensurate increase in green turtle numbers. A detailed exploration of this perception reveals a complex set of mechanisms for this conflict, invoking both direct (first order) factors as well as more involved (second order) interactions as triggers of this conflict. Most directly, 80% of fishers complained of turtles being responsible for damaging gear, on average within the last 90 days. Additionally, many respondents also argued that turtles scared fish away from nets by their movements, causing declines in catch. Apart from these direct mechanisms of loss, many fishers also alluded to more complex second-order mechanisms of conflict. More than 46% of interviewees were of the opinion that green turtles cause declines in adult fish usage of the meadow by overgrazing the seagrass. According to fishers, this has caused declines in several seagrass specialist fish, and, importantly, has caused a decline in sprats (*Spratelloides delicatulus*), a species important to the commercial mainstay tuna fishery. These second-order mechanisms are characteristically different from first order conflict in that they are an outcome of a species affecting a resource not directly valued, but whose modification results in real or perceived losses of resources valued by humans. Although they may be difficult to observe and measure, they may, nonetheless, have as great an impact on species conservation as more direct conflict mechanisms. In the case of Agatti, the combination of first- and second-order conflict has resulted in perceived losses of fish catch for fishers, and a vociferous antipathy toward green turtle conservation by the fishing community, often leading to clandestine mortality events.

THE PERCEPTIONS OF LOCAL COMMUNITIES TOWARDS MARINE PROTECTED AREAS AND THE CONSERVATION OF THE LOGGERHEAD SEA TURTLE: THE CASE STUDY OF THE BAY OF KYPARISSIA

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Over the past two decades there has been noticeable progress towards the conservation of the marine environment in Greece, largely as a result of efforts made by non-governmental organisations (NGOs). However, the conservation of marine and coastal resources by the Government and NGOs often leads to conflict with local communities, emphasising the need for integrated coastal management (ICM) involving all stakeholders. This study examines the Bay of Kyparissia which stretches for approximately 42 km along the western coast of Peloponnesus, Greece. It is an area recognised for its international ecological importance, comprising the second most important nesting area in the Mediterranean Sea for the loggerhead sea turtle (*Caretta caretta*) and it is designated as a Natura 2000 site for its extensive sand dune systems and coastal coniferous forest. The study investigated the potential of establishing a National Marine Park within the Bay of Kyparissia, primarily for the conservation of *Caretta caretta* and the coastal zone. Stakeholders, including local authorities and members of the community, as well as tourists were examined using both qualitative and quantitative methods to identify their perceptions and attitudes towards the conservation

of sea turtles and the possibility of creating a National Marine Park in the Bay. The study identified a significant prejudice against Marine Protected Areas, predominantly amongst the local community. In particular, extreme negativity towards protected areas was recorded as fear of restrictions to development. In contrast, foreign tourists indicated positive attitudes towards Marine Protected Areas, exhibiting greater understanding and knowledge of conservation management. This paper, recommends increased efforts to raise public awareness among the local community regarding Marine Protected Areas, and presents ways of effectively engaging stakeholders for future management initiatives.

CONSERVATION AND ISLAM: INFUSING TURTLE CONSERVATION MESSAGES IN ISLAMIC SERMONS IN MALAYSIA

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Religion plays a fundamental and elemental role in the lives of many Malaysians. This is nowhere more evident than in the state of Terengganu in Peninsula Malaysia, which has a predominantly Muslim population. Recognizing that Islamic teachings and religious leaders (Imams) are very influential and greatly respected, especially within communities of this state, WWF-Malaysia facilitated a series of workshops for Islamic leaders in Terengganu to infuse Friday sermons with specific species/wildlife conservation messages. Islamic teachings have various sets of discourse on environmental issues, and allow for the infusion of conservation messages into these teachings. In Terengganu, the issues of human threats to the survival of turtles and the conservation of this species were incorporated with existing religious texts. The sermon infused with turtle conservation messages was read in 428 mosques in Terengganu on 21 November 2008. A survey was conducted at four of the mosques in Terengganuo to assess levels of concern and awareness on turtle conservation among male Muslims who attended the Friday prayer sermon. The result indicated that the Islamic sermon elevated public concern and awareness on turtle conservation issues. The support of religious leaders and mosques for species conservation can be an effective platform to elevate the communities' concern and awareness on conservation issues. It is hoped that this approach will generate interest and increased participation of local communities in conservation initiatives, specifically in community-based turtle conservation.

HYPOTHETICAL TORTOISESHELL ROADS TOWARD EUROPE BETWEEN THE 1ST AND THE 17TH CENTURIES AD

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In the artistic history of humanity, tortoiseshell from sea turtles has been considered a highly-valued commercial and precious material. It was used as an ornament for beds, precious furniture, cabinets, and mirrors. From the 16th century, tortoiseshell was commonly used in marquetry of royal furniture, particularly by the great cabinet-maker Andre-Charles Boulle at the Castle of Versailles and for Louis XIV. In the 18th century, hawksbill (*Eretmochelys imbricata*) shell was replaced by the green turtle (*Chelonia mydas*) shell, especially for furniture. In the present work, we will try to determine which maritime and land roads were taken to supply tortoiseshell to European artists and craftsmen from various continents and periods. The Silk Road was one of the commercial land roads for tortoiseshell. Ideally, the purpose of this research would be to discover by genetic analysis the origin of the tortoiseshell samples used in precious objects stored today in the museums and private collections.

*CHANGING TASTE PREFERENCES, MARKET DEMANDS AND TRADITIONS IN PEARL LAGOON, NICARAGUA: A COMMUNITY RELIANT ON *CHELONIA MYDAS* FOR INCOME AND NUTRITION

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The social system of Caribbean Nicaragua has its own cultural logic that explains the eating habits of Indigenous communities that rely on and prefer sea turtle meat to other available sources of protein. Nutritional costs and benefits play a fundamental role in this reliance, yet there are ecological, economic and cultural factors that may be just as if not more important than the nutritional value of turtle meat. Caribbean Nicaraguans have legally harvested *Chelonia mydas* for more than 400 years, and continue to rely on the species as an inexpensive and tasty source of protein and income. Green turtles were embedded in the local ethic of subsistence, which traditionally regulated natural resource use through debts and obligations to relatives and other community members that could be paid/re-paid in the form of turtle meat or other resources. Since then, through Nicaragua's increasing integration into the global economy, things have changed significantly. Prior to arrival of the British on Nicaragua's Caribbean coast in the mid-1900s, there was no need for money in the indigenous communities since there was nowhere to earn it or spend it. After the English opened their first trade company in Caribbean Nicaragua around 1634, outside contact and trade became part of Miskito society and significantly altered the traditional culture, subsistence livelihoods and natural resources. Cash-based market systems began to divert turtle meat from the traditional intra-village exchange system to individuals and outsiders, placing considerable strain on kinship relationships. From 1967 to 1977, green turtles were harvested for both local and foreign consumption, including annual exports to the U.S. from turtle packing plants in Nicaragua in excess of 10,000 turtles. Although the processing plants have been closed for over 30 years after Nicaragua became a signatory to CITES in 1977, the local demand for turtle meat in coastal communities has continued. This case study focuses on communities of mixed Miskito and Creole ethnicity based in the 5,200 km² Pearl Lagoon Basin (RAAS). Data were collected in the fishing village of Pearl Lagoon (approximately 2,540 inhabitants) over a ten-month period in 2006 and 2008. Progressive market incorporation of Pearl Lagoon, a coastal community of Afro-Caribbean Creoles and Miskito Indians, has resulted in alterations of traditional sea turtle harvests, historical protein taste preferences and kinship relationships. Following themes of cultural ecology and ecological anthropology, this research illustrates some of these cultural adaptations, with a particular focus on changing meat taste preferences. Taste preference is one aspect of local culture that is influenced by both the environment and the ever-changing relationships between these coastal communities and green turtles. Local level data for this paper was primarily collected using ethnographic methods. Data collection consisted of participant observation, semi-structured interviews and ranking exercises with community members. Organized data collection was supplemented by observations of everyday community activities, particularly: variations in market prices, meat availability and consumer preferences and butchery of sea turtles. In addition, observations were made during interviews at the household level, and through meetings with community leaders on sea turtle harvest restrictions.

*PRINCIPAL-AGENT MODELS OF SEA TURTLE CONSERVATION INCENTIVE AGREEMENTS

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A number of sea turtle conservation programs have implemented conservation incentive agreements and payment schemes. These are negotiated contracts by which resource users forego destructive activities in exchange for direct benefits provided by conservation investors. The benefits are intended to be conditional on conservation performance. Ferraro and Gjertsen (2009) review nine such sea turtle conservation projects from across the globe. Despite the increasing number of these projects, evidence regarding their performance is sparse, and the concept lacks a theoretical treatment in the literature. We develop four single-period game theoretic models to describe

conservation payment contracts for sea turtle nesting beaches and analyze the likely consequences of different designs. All of the models include a principal (the NGO or government making the payments) and an agent (the individual whose behavior the principal seeks to change). The principal must make decisions regarding the payment to offer and the monitoring of the agent's behavior. The agent must choose whether to conserve or harvest. The models differ with respect to the timing, size, and form of the payment, and the nature of monitoring, all of which may be subject to some uncertainty on the part of one or both parties. We found that none of our simple designs resulted unequivocally in a first-best solution, i.e. an equilibrium in which conservation is achieved. However, one of the contract designs can result in the optimal strategy of conservation under certain conditions. Of the projects in Ferraro and Gjertsen (2009), most have continued to operate for many years. While it appears that some of these are unsuccessful for reasons our simple game theoretic models predict (despite their continued existence), others have evidently been successful. These cases motivate the extension of our theoretical models to a repeated game context, which permit a richer set of equilibria to exist that rely on reputational effects and the ability to renegotiate the terms of the contract under certain conditions. The repeated game context also allows for additional refinements and explorations of such issues as differing rates of time preference between the principal (the NGO) and the agent (villages).

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*PERCEPTIONS, PARTICIPATION AND POACHING: IDENTIFYING THE DRIVERS BEHIND ILLEGAL SEA TURTLE USE IN COMMUNITIES ADJACENT TO CAHUITA NATIONAL PARK, COSTA RICA

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The aim of this study was to identify the drivers underpinning illegal sea turtle harvest by residents of communities adjacent to Cahuita National Park on the Caribbean coast of Costa Rica. Representatives from three adjacent communities at varying geographical distance from the National Park, Cahuita town, Hone Creek and Playa Negra, were interviewed using semi-structured face-to-face interviews, designed to elicit perceptions towards sea turtles and management of the National Park. Factors identified as influencing poaching behaviour were economic drivers, perceived legitimacy, governance, personal morality, socio-cultural norms and awareness of regulations. In communities where income levels are variable, such as Hone Creek and Playa Negra, economic factors were identified as the major drivers of poaching behaviour. This was due to the consumptive value of illegal trade in sea turtle eggs as a source of income. Conversely, the key drivers behind sea turtle use in Cahuita town were found to be non-consumptive through economic gain from turtle-associated tourism and social influence, resulting in high levels of compliance towards National Park regulations. Lack of awareness towards sea turtle conservation regulations was recognised as a key factor driving behaviour in all of the communities surveyed, influencing personal morals and perceived legitimacy of regulations. Future management strategies should strive to involve local communities in sea turtle conservation practice as a means of enhancing voluntary compliance towards regulations. Awareness raising campaigns through educational workshops in all communities associated with the National Park are recommended. These should be interactive, enabling open communication and transparency of information between all stakeholder groups and institutional levels, to facilitate change and progress towards both ecological and socio-economic viability of the Cahuita National Park.

*WHO'S HELPING, WHO'S HURTING, AND WHO'S IN CHARGE? CONFLICTING PERCEPTIONS OF CONSERVATION, TOURISM, AND CHANGE IN TORTUGUERO COSTA RICA

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Domains, responsibilities and jurisdictions pertaining to sea turtle conservation and enforcement in Tortuguero National Park (Costa Rica) are clear, and entrenched in national and international laws. Park staff (who run Tortuguero National Park, which is part of the SINAC system and run by MINAET, the Costa Rican national Ministry of the Environment, Energy, and Telecommunications) are in charge of Park management and turtle-related enforcement both within and beyond park boundaries. The Caribbean Conservation Corporation, a sea turtle conservation NGO with a long history of working in Tortuguero, and the police sometimes assist Park staff with addressing sea turtle-related infractions (e.g. they might report or assist in alleged poaching incidents), but they must defer to Park staff. The CCC and the Park staff also work together in local conservation efforts, and are sometimes aided by other interested groups (e.g. visiting volunteer groups; visiting NGOs). Other distributions of responsibilities, divisions of labour, and management and enforcement jurisdictions related to conservation, development (especially tourism), and environmental management are less clear. This is encouraged by the lack of a master plan that lays out rules, responsibilities, and restrictions regarding tourism development (and related environmental management) in the area. It is therefore unclear who is responsible for what, within this growing ecotourism-based community and industry. Much is left up to the individual in terms of understanding 'how things work', and their understanding is intimately linked to their experiences in Tortuguero. In this paper, we examine the degrees of overlap and divergence between volunteer, (other) tourist, and local perceptions of conservation, tourism, and change in Tortuguero, Costa Rica. We highlight respondent narratives regarding perceived: responsibility and jurisdiction, blame, contributions and costs, and divergent understandings of 'who is in charge' with respect to conservation, development, turtle tourism, and environmental management. The paper incorporates 1148 tourist surveys (2003–2004; 2008), 70+ local interviews (2003–2004), and 33 volunteer interviews collected by Campbell and Smith (1999–2000). While our paper is based on empirical data, we do not concentrate on data analysis and results. This paper is a discussion of respondent themes generated in our ongoing, cumulative qualitative analysis (conducted using grounded theory, thematic coding, and various qualitative analysis software packages). We present a variety of viewpoints on conservation, development, and change in Tortuguero in order to illustrate the heterogeneous experiences of tourists, local people and other residents, 'experts', and volunteers. At the same time, we highlight patterns of convergence. We consider the potential implications for the future of conservation, turtle tourism, and environmental management in Tortuguero; we present these themes as co-existing understandings of ecotourism in practice, and we contemplate their significance locally, and beyond.

*THE CHALLENGE OF AN ALTERNATIVE: OFFSETTING LOSSES FROM CONSERVATION THROUGH LIVELIHOOD PROGRAMMES

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Orissa on the east coast of India has a matrix of legislative measures for the protection of olive ridley turtles that come ashore at three well-known mass-nesting sites on its coast. In 1997 the Gahirmatha National Park, a Marine Protected Area, was established which virtually rendered a large proportion of fishing practices in the region illegal. In the other sites, at Devi river mouth and Rushikulya, legislation has been imposed by the government which restricts various fishing practices. While the restrictions themselves do not affect all categories of fishers, neither the fisher community nor the law enforcement officers at the local level have detailed knowledge about legal prohibitions and exemptions. This has led to allegations from the fisher community of harassment by forest department officials, resulting in a loss of fishing days and confiscation of fishing catch and gear. Loss of fishing catch, a reduction of fishing effort and a direct loss of income are all phenomena reported in the different Marine

Protected Areas in India. The question of compensation of these losses is a particularly pervasive but vexed one. The nature and extent of fishing effort within the boundaries of these restricted fishing zones in Orissa has been estimated variously by different agencies. This makes it difficult to agree on the losses from conservation restrictions and also to plan alternative or supplementary livelihoods. The State Government of Orissa has announced different packages to compensate the losses, however, none of these have seen the light of day. Non-government agencies, including conservation organisations and the Orissa Traditional Fishworkers' Union, have proposed their own compensation packages and livelihood options. Our study focuses on the efforts by government and non-government agencies, to offset these loses. The Orissa Marine Resources Conservation Consortium was set up in 2004 as a common platform to resolve problems related to conservation, through collaborative efforts in the State. Through one of its projects, it aimed at offsetting some of the losses to the fishing community by trying to set up and strengthen existing enterprise-related models of conservation. The project aimed at setting up experimental livelihood activities and involving members from the fishing community in enterprise development. This was done with a view to providing an alternative income to those who might be affected by the fishing restrictions in turtle breeding and nesting areas. We examine how effective the compensation efforts have been and what factors influence the achievement of livelihoods generation objectives. We describe the economic and social costs of setting up enterprise related activities to offset conservation losses. Our findings also discuss critical questions related to the enterprise-related model of conservation such as – what are the key drivers of enterprise related development efforts as identified by various stakeholders. Is it possible to satisfactorily compensate all 'victims' of conservation? In conclusion, we re-evaluate the current loci of conservation efforts in light of the challenge of implementing compensation efforts.

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*A COMMODITY CHAIN ANALYSIS OF THE MARINE TURTLE HARVEST IN SOUTH CAICOS, THE TURKS AND CAICOS ISLANDS

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Marine turtle fisheries in the Caribbean islands are often perceived to be 'remnant' fisheries, limited in scope and declining, with most capture incidental and with only a few dedicated turtle fishers remaining. Therefore management of turtle fisheries is not treated as a priority by the relevant authorities; when action is taken, it is often to close what are perceived to be economically unimportant fisheries. In this study we explored one such fishery based in South Caicos in the Turks and Caicos Islands and assessed the assumption that this is an 'unimportant' fishery. We conducted a commodity-chain analysis based on ethnographic and interview data related to over 100 turtle captures collected by a dedicated field researcher embedded in the South Caicos community since November 2008. First, we examined fishers' motivations for capturing turtles, both through opportunistic and directed take, and assessed these motivations in relation to the changing contexts of the commercially important spiny lobster, conch and scale-fish fisheries. Second, we investigated the transactions and relationships between fishers, retailers and consumers, and determined how the various links in the commodity chain influence the nature of the South Caicos turtle harvest. Our findings highlight the symbolic value that fishers and consumers attach to turtle harvest, the socio-economic value of turtle meat gifting by fishers and consumers to other members of the South Caicos community, and how all turtle fishing activity has to be understood in the context of other fishing activity. We discuss how the study's findings could inform an ongoing, collaborative project to improve management of the Turks and Caicos Islands' turtle fishery through changes in national legislation and development of new management measures and regimes.

*A NETWORK APPROACH TO ASSESSING MARINE RESOURCE GOVERNANCE: AN AUSTRALIAN SEA TURTLE CASE STUDY

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One of the significant problems associated with natural resource management is the mismatch between the scale of management and scale of ecological processes or units being managed. Scale mismatch between institutional and ecological scales can contribute to a decrease in social-ecological resilience through ecosystem mismanagement, resulting in a decrease in human well-being. "Bridging" organizations that link stakeholders at different scales may help resolve mismatch and increase resilience in the management network. Some authors also suggest that a balance between institutional redundancy and heterogeneity within social-ecological systems can similarly help resolve scale issues and enhance social resilience, but few case studies have been conducted to test the practical implications of this theory. To help fill this knowledge gap our study examined co-management networks for green turtles in two case study regions of Australia—the Torres Strait and Great Barrier Reef World Heritage Area (GBRWHA)—to determine (1) the extent of institutional redundancy in each network, and stakeholder perceptions of this redundancy, and whether institutional redundancy confers social resilience to these particular management frameworks, and (2) what other network structure qualities, such as centrality and density, may influence network resilience. We conducted in-depth semi-structured interviews with key-informant stakeholders (n = 28) in dugong and turtle management at all relevant institutional scales. We thematically coded interview data using QSR NVivo Qualitative data analysis software and then created network matrices defining collaborative and competitive relationships between stakeholder organizations based on interview responses. Our results indicate that institutional redundancy and diversity is high in the GBRWHA network, but institutional capacity/stability is relatively lower. Policy influence tended to flow from upper level centralized institutions to small scale community-based institutions while information tended to flow upward. Conversely, in Torres Strait, institutional redundancy is low, but stability/capacity is high. One key agency, the Torres Strait Regional Authority (TSRA) acts as a "bridging organization", playing an important role in linking local and regional scales and enhancing social resilience. However the TSRA may also act as a gatekeeper, limiting more diverse communication. Management responsibility in Torres Strait took place more often at the community level, with a two-way flow of knowledge and information between communities and regional bodies, mediated by the TSRA. Both case study networks are defined by a trade-off between the likelihood of collapse (network susceptibility) and the seriousness of consequences (network stability). Therefore, the 'preferred' structure for a management framework is dependent on the particular cultural, political, and socio-economic context (i.e. there is no one ideal framework). Our findings lend support to the theory that cross-scale management linkages that balance institutional redundancy with heterogeneity of linkages will likely lead to more resilient co-management arrangements and provide better protection for marine wildlife while meeting the needs of stakeholders at multiple levels.

EXPOSING THE ILLEGAL TRADE IN TURTLE PRODUCTS IN UNITED REPUBLIC OF TANZANIA

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Following several unverified reports detailing the illegal trade in turtle products (meat, shells and oil) in the Dar es Salaam area, surveys were undertaken to assess the true status of this trade. Potential landing sites for turtle products were visited by undercover investigators in July and August 2008 and again in August 2009. During the first survey in 2008, 48 people were informally interviewed over a period of seven weeks. Turtle carapaces were found to be on sale at several markets in the Dar es Salaam area, fetching US $3–12 depending on size. Shells are usually varnished and then sold for decoration to both Tanzanians and Europeans. Occasionally they are used as water containers for livestock. It is believed that livestock production will increase if animals drink water from a turtle carapace. Turtles are reported to be caught daily in fishing nets and with hand lines. The turtles are brought in to the landing sites live for sale, normally early in the morning or late in the evening, to avoid detection. Turtle meat is sold regularly at the markets, particularly to Chinese buyers. The meat is believed to improve the immune system. Turtle scutes and oil

are also sold for medicinal purposes. During the second survey, 39 interviews were held with traders who all admitted to knowing that turtles are protected. Trade is done in secret and is thought to be the result of the high level of turtle bycatch in fishing nets. Traders reported that fishers never release captured turtles but bring them to the market for slaughter and subsequent sale. The lack of a comprehensive strategy to reduce turtle bycatch in Tanzania is facilitating the trade in turtle products. In addition, poor enforcement of laws controlling the trade encourages illegal activities to continue. Fishers and traders are aware that trade in turtle products is illegal but there is no deterrent. The names and contact details of known traders have been handed to the relevant authorities for action but to date, no traders have been apprehended or penalised. There is a need for improved enforcement at fish landing sites and markets, together with an awareness and education campaign targeting fishers and traders in turtle products.

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