Sirenews

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IN THIS ISSUE:

RISING TO THE CHALLENGE OF SCALE MISMATCH IN DUGONG CONSERVATION

In a recent paper in *Ecology and Society*, Cumming et al. (2006) points out the dangers of what they refer to as scale mismatches in social-ecological systems. They hypothesize that many of the problems encountered by societies in managing natural resources arise because of the mismatch between the scale of management and the scale(s) of the ecological processes being managed.

The dugong has a huge range. Its extent of occurrence is some 140,000 km of coastline across 48 countries and includes tropical and subtropical coastal and island waters from east Africa to Vanuatu, between about 26^{o} and 27^{o} north and south of the equator. Studies of dugong movements in Australia (Shepperd et al. 2006) indicate that individual dugongs can move hundreds of kilometers in a few days. The genetic evidence (McDonald 2005) also indicates that the appropriate biological scale for dugong management is hundreds of kilometers. Thus the potential for scale mismatch in dugong management is considerable and can only be prevented by international collaboration.

The development of a Memorandum of Understanding (MoU) for the conservation of dugongs under the auspices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS), was agreed by a recommendation adopted at the seventh CMS Conference of the Parties in 2002, and confirmed at the eighth CMS Conference of the Parties in 2005. Two meetings in Bangkok in 2005 and 2006 developed and considered a draft text of the MoU. The final draft proposal of the MoU and associated Conservation and Management Plan were endorsed at the second meeting in Bangkok in May 2006. CMS circulated the adopted MoU and Conservation and Management Plan to the range states for final comments and notification of intention to sign. The comments received in response indicate that there were no major objections to the final draft. The texts are now finalised and have been translated into French, Arabic and Chinese (see http://www.cms.int/bodies/meetings/regional/dugong/pdf/docs_mtg3/Doc_04_Note_of_the_Secretariat.pdf).

The MoU is a non-binding legal instrument that helps to protect and conserve dugongs. The associated

UNION INTERNATIONALE POUR LA CONSERVATION DE LA NATURE ET DE SES RESSOURCES

INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES

Commission de la sauvegarde des especes-Species Survival Commission

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Conservation and Management Plan is divided into nine objectives and an annex containing a list of examples of specific activities that could be undertaken with a view to achieving these goals. Objectives relate to the protection and conservation of the dugong and its habitat and the promotion of the implementation of the MoU. The objectives also refer to improving awareness and education, the legal framework, as well as international cooperation.

The MoU on the Conservation and Management of Dugongs and their Habitats throughout their Range is scheduled to be signed in Abu Dhabi in the United Arab Emirates on October 31 2007. The signing will be preceded by two concurrent workshops concerning the implementation of the Dugong Conservation and Management Plan in: (i) East Indian Ocean and the Pacific Ocean and (ii) West Indian Ocean sub-regions. It is intended that the outcomes of the two workshops and their integration will facilitate the implementation of the MoU and the Conservation and Management Plan with support from the range states and other stakeholders, such as the United Nations Environment Programme (UNEP) and various NGOs and IGOs dealing with dugong conservation. Another advantage of these initiatives will be to identify research and implementing projects, including financial support from governments and other international institutions.

I look forward to the MoU heralding a new era in dugong conservation, an era that recognizes the dugongs do not recognize lines on maps and in which management and research are coordinated at scales relevant to the dugong's biology. **-Helene Marsh**

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FLORIDA MANATEE VOTE POSTPONED

Following a request by Governor Charlie Crist, the Florida Fish and Wildlife Conservation Commission postponed a vote to reclassify Florida manatees from "endangered" to "threatened" status. At their September 12th meeting the commissioners voted to defer the decision until at least December, when their next meeting will take place in Key Largo, FL. The letter from Governor Crist, dated September 10th, urged the Commission to postpone the decision to allow "the new members of the Commission more time to evaluate this complex issue and ensure that they, along with the rest of the Commission, are fully prepared to vote on an item of such gravity." Governor Crist referred to the manatee as "one of our state's most beloved natural resources", and applauded the Commission for diligently working to resolve the status issues of the species. The final version of the FWC Manatee Management Plan can be accessed at http://myfwc.com/imperiledspecies/plans/Manatee-Mgmt-Plan.pdf. **-CRT**

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Domning's 1996 *Bibliography and Index of the Sirenia and Desmostylia* is now accessible online as part of the Smithsonian Contributions to Paleobiology series at http://www.sil.si.edu/SmithsonianContributions/Paleobiology/sc_RecordSingle.cfm?filename=SCtP-0080.

It can be viewed in both PDF and full-text modes.

Efforts are continuing to make available online the underlying database, with post-1994 updates. It is hoped that this will be accomplished in the next few months, thanks to the help of Caryn Self-Sullivan and a volunteer programmer. -**D. Domning**

SIRENIAN POPULATION GENETICS CONFERENCE
20-21 APRIL 2008, ORLANDO, FLORIDA

The US Geological Survey will be holding a Sirenian Population Genetics Conference in Orlando, Florida on 20-21 April 2008. This meeting will be held just before the third triennial Florida Marine Mammal Health Conference (http://conference.ifas.ufl.edu/marinemammal/index.htm) which will be convened at Marineland (near St. Augustine), Florida between 22-25 April.

If you are interested in attending The Sirenian Population Genetics Conference please send me your email address and I will add your name to a notification list. Registration details to follow shortly; early registration before 17 March 2008 will be free, late registration after 17 March may be assessed a small fee. The format of the genetics conference will include one day of detailed instruction by invited speakers on the utility of genetic tools for determining population structure, and a second day consisting of 15 minute presentations on sirenian genetics. Please contact me also if you are interested in submitting an oral presentation or a poster. I would like a tentative title and a sentence about the importance to conservation of your contribution. The final submission deadline for presentations will be 17 March. Transportation following the conference on 22 April from Orlando to Marineland will be provided at a nominal rate. This venue will afford a great opportunity for field biologists, researchers, managers, and clinicians to get together to discuss issues related to sirenian conservation genetics and population management. -**Bob Bonde** (rbonde@usgs.gov)

FUTURE FORMAT OF *SIRENEWS*

We have received very little feedback following our request for comments in the previous edition of *Sirenews* regarding the preferred format of the newsletter (electronic or hardcopy). Therefore, we are moving to an electronic version of the newsletter as of this edition to save on printing and postage costs. We will continue to print a small number of newsletters for libraries, etc. If the electronic version does not meet your needs please contact the editors. –**CRT**

CONSERVATION PROSPECTS FOR THE WEST AFRICAN MANATEE "*Trichechus senegalensis*"

Phase I of the West African Manatee Conservation Project will come to an end in December 2007. Between November 2004 and that date, much will have been achieved. For the first time in the species' history, regional action has been carried out in favour of its conservation, making it possible to improve knowledge of the West African manatee. Thanks to the surveys conducted in the six PRCM countries (Mauritania, Senegal, The Gambia, Guinea, Guinea Bissau and Sierra Leone) and the compilation of national reports in the other African countries, a good database now exists on the status of the species, in particular its distribution, populations, socioeconomic value, legal status and the recommendations for its conservation. Communication tools have been developed for the general public (T-shirts, folders, posters, website), for experts (scientific booklet under development) and for young people (school book under development). The development of a communication strategy has made it possible to identify relevant actions for better sensitisation on the importance of the species. Lastly, this phase will have allowed all the PRCM national partners to carry out field work (sensitisation) and exchange visits.

Given the significant results achieved, a Project Phase II is being developed by Wetlands International. This will be about implementing the regional strategy for the conservation of the manatee in the PRCM countries, in particular by improving the legislation, developing research, communication and education, and conducting practical actions. Furthermore, the launch of the ***West African Marine and Coastal Biodiversity Network – BIOMAC*** is planned in order to consolidate the achievements of the PRCM in the field of species and habitat conservation. In recognizing that resources are transboundary, that key habitats and species face similar challenges and that the same players are involved in their protection, the PRCM has agreed upon the establishment of a West African Marine and Coastal Biodiversity Network to ensure the consistency of interventions and promote experience exchanges. BIOMAC will make it possible to institute practical field actions while building the capacity of local players who have to take responsibility for the future of their region.

-**Dr. Mame Dagou DIOP (**Wetlands International: dagouwet@gmail.com), and **Ms. Emma Greatrix** (Project Development Officer, Wetlands International: emmawet@gmail.com)

CONSERVATION OF THE WEST AFRICAN MANATEE *Trichechus senegalensis*: WETLANDS INTERNATIONAL SUPPORTS SCIENTIFIC RESEARCH

Still the least known living Sirenian, the West African Manatee is one of the "forgotten" mammals. Presently, only a handful of scientists are conducting research on the distribution and biology of the species. It is true that there is well-established relative knowledge about how the species is used, especially its socio-ethnologic and economic values. In contrast, there is very little information about its biology (reproduction), population, and distribution, posing major problems for monitoring the species. There is also plenty of speculation about its reproduction and diet ("the manatee eats fish"). In order to overcome these shortcomings, Wetlands International is supporting research on the species through partnership protocols with institutions in the West African coastal sub-region and in Europe.

This is how a doctoral student at Ecole Inter-Etats de Sciences et Médecine Vétérinaires (EISMV) in Dakar has been conducting research on the bio-ecology of *Trichechus senegalensis* since January 2007. Her work is focused on the comparison of two main types of manatee habitat and the gene characterisation of the animals living in each of these. The investigation sites are the River Senegal Delta (a freshwater ecosystem) and the Saloum Delta (a brackish water ecosystem). At the end of this work, we will have a better knowledge and understanding of the biology of the species, as well as knowledge of the gene map of these populations.

To improve scientific communications on the species, Wetlands International is developing a booklet on its biology. This document is being developed by a Masters level intern from the University of Groningen in Germany. The booklet deals with issues pertaining to the systematics, morphology, dentition, diet, habitat and distribution, reproduction and conservation status of the West African Manatee.

Finally, a manatee website is under development which will provide information on the species and the project (http://www.tsenegalensis.org). -**Dr. Mame Dagou DIOP** (Wetlands International dagouwet@gmail.com) and **Ms. Prisca Ndour** (EISMV, caprisnd@yahoo.fr)

BYCATCH OF NON-TARGETED MARINE SPECIES IN THE WESTERN INDIAN OCEAN: PROBLEMS AND MITIGATION MEASURES.

From 13 to 15 November 2006, representatives from Western Indian Ocean (WIO) countries and from other regions (USA, Australia, Sri Lanka) participated in a workshop to collate available information and assess the potential impact of bycatch on non-targeted marine species in the WIO, with a focus on marine mammals and turtles. This workshop was organized by the NGO Sea Sense, based in Tanzania, and by the University of La Rochelle, France. The three-day workshop was held on the island of Mayotte (France) at *Hôtel Sakouli* and was funded by the Western Indian Ocean Marine Science Association through a MASMA (Marine Science for Management) grant. The aims of the workshop were to: 1. bring together relevant marine mammal and turtle scientists, fishery biologists, conservationists and managers in the region to share ideas and exchange information on bycatch of non-targeted marine species in the WIO; 2. review the level of threat from fisheries, both coastal and pelagic, in the WIO region; 3. discuss and resolve common issues relating to bycatch; 4. discuss and resolve common issues relating to data collection and analysis, survey techniques, and specific threats (other than by-catch) such as eco-tourism, pollution, habitat destruction/disturbance and boat collisions; and 5. produce recommendations for research and management, fund-raising and future regional and international collaboration. Presentations were given on the regional status and conservation of turtles and marine mammals, in the context of fishery-related mortality. The workshop agreed that the coastal gillnet fishery poses a serious threat to turtles, dugongs and cetaceans in the WIO region. There are currently no measures to reduce bycatch in this fishery. Prawn trawling also poses a threat, particularly to turtles. It was acknowledged that while turtles, dugongs, cetaceans and sharks are all impacted by fishing activities in the WIO region, the highest priority is the dugong which is severely threatened from gillnetting and habitat disturbance. The establishment of a regional dugong research and conservation programme has been identified as a high priority. A rapid regional assessment of gillnet and prawn trawl fisheries was also considered a high priority to assess the level of threat from these gears on non-targeted marine species. Practical ways to reduce bycatch were identified, including convincing decision-makers of the importance of reducing bycatch due to the high tourism value placed on marine mammals and turtles. - **Jeremy KISZKA[1, 2] & Catharine MUIR[3] (Convenors)** ([1] CRELA (Centre de Recherche sur les Ecosystèmes Littoraux Anthropisés), UMR 6217, CNRS-IFREMER-Université de La Rochelle, Avenue Michel Crépeau, F-17071, La Rochelle, France. * Email : jeremy.kiszka@wanadoo.fr; [2] Direction de l'Environnement et du Développement Durable, Collectivité Départementale de Mayotte. BP 101 F-97600 Mamoudzou, Mayotte; [3] Sea Sense, P O Box 105044, Dar es Salaam, Tanzania)

LOCAL NEWS

DOMINICAN REPUBLIC

Antillean Manatees in Caño Estero Hondo, Dominican Republic. There have been few scientific studies on manatees in the Dominican Republic (Belitsky & Belitsky, 1980; Ottenwalder, 1995; Pugibet & Vega, 2000). Nevertheless, manatees are found around the country, especially along the north coast. Caño Estero Hondo is a coastal saltwater lagoon, located in the northwest coast. It is connected via a narrow entry channel to a shallow bay protected by a reef, included within the Marine Mammal Sanctuary of Estero Hondo, created in 2004. With the aim of gathering information on the actual status of manatees in the Sanctuary, and contributing to the knowledge and management of the species, a preliminary study was started in January 2007 by the Centro de Investigaciones de Biología Marina (CIBIMA) of the Universidad Autónoma de Santo Domingo (UASD). The study is based on interviews with locals, habitat sampling for baseline environmental variables, and manatee boat surveys using a non-invasive 30 minute point-scan methodology in selected stations, following Self-Sullivan et al. (2003).

Locals are knowledgeable about manatees. Of 138 interviews carried out in six communities near the lagoon, 95% of respondents identified manatees correctly and 86% have seen them personally. A total of 173 manatee sightings were reported by interviewees in the past. Analysis of the death cases reported show that at least 11 to 12 manatees died in the study area between 1996 and 2007, from both natural causes and illegal hunting. Excluding the death cases and reports from people who did not see the manatees personally or did not remember the exact place where the sighting occurred, 61% of 119 reports have occurred in Caño Estero Hondo. According to 67% of respondents, manatees are present during all months of the year, and 76% believe that they travel daily in and out of this coastal lagoon. All respondents are aware of the status of the manatee as a protected species, and 70% believe that the manatee population has increased in the last 10 years. Of the respondents who stated the reason for the increase, the most popular answers were: due to an increase in protection efforts (45%), and due to reproduction (23%).

In terms of habitat characterization, surface water temperature averages 30.4 °C and the average depth is 1.91 m. Salinity can vary from 9 to 37 ‰ due to rains and naturally occurring freshwater effluents, of which six have been identified. The dominant seagrass species are *Thalassia testudinum* and *Syringodium filiforme*, but *Halodule wrightii* and *Halophila decipiens* are also present.

During 2007, 147 hours of effort have resulted in 49 sightings (18 within the point-scan sampling design and 31 opportunistic). Of the latter, 12 were from fixed point land surveys. The maximum number of manatees seen simultaneously during one sighting was nine, including at least three and possibly four calves. Manatees were most often observed at either end of the entry channel to the lagoon, where seagrass was more abundant. Manatees were frequently observed in a resting hole identified in the west arm of the lagoon. Although illusive and evasive, manatees have been observed feeding, resting, traveling, socializing and milling within the Caño Estero Hondo. Manatees were observed during each month from March to August 2007. More information on distribution and habitat use will be available as field work is completed by the end of this year.

To answer questions regarding individuals and their movements, we would like to start a manatee tagging and tracking project. We are seeking training opportunities and partnership with experts in order to achieve it. This preliminary study was made possible with the support from the Secretaría de Estado de Educación Superior Ciencia y Tecnología (SEESCyT) and the Fundación Brugal. We are grateful to Dr. Caryn Self-Sullivan for training in the use of the point-scan methodology, expert advice on our research design and field work, and her continuous support of the project. **-Haydée M. Domínguez Tejo** (Centro de Investigaciones de Biología Marina CIBIMA. Universidad Autónoma de Santo Domingo. Aristides F. Cabral, esquina Ortega Frier. Ciudad Universitaria. Santo Domingo. Tel. 809-686-3250. E-mail: hdominguezt@gmail.com)

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EAST AFRICA

Dugongs in eastern Africa: balancing on the brink. The dugong (*Dugong dugon*) is the only herbivorous mammal that is strictly marine, and the only member of the family Dugongidae. This is the most abundant sirenian, and it occurs in at least 48 countries and territories of the tropical and subtropical Indo-Pacific region, from east Africa to Vanuatu, covering a coastline of approximately 140,000 km (Marsh et al., 2002). Of the four extant sirenians, dugongs have the largest range and population size. However, due to the coastal habitat of dugongs, they face many threats including hunting, bycatch in fishing nets (especially gillnets), habitat degradation and pollution of coastal ecosystems. At the global scale, the dugong is currently classified as Vulnerable by IUCN. However, its conservation status is highly variable throughout its range with the largest populations occurring in Australia, south-east Asia and in the Arabian Gulf (Marsh et al., 2002).

The eastern Africa coast marks the western-most boundary of the dugong's global range. This geographical area has a mainland coast of over 11,000 km and is home to some of the world's most important coastal and marine environments and resources providing important feeding and calving grounds for dugongs as well as other endangered marine species. Two marine ecoregions have been identified in the region representing globally outstanding examples of marine and coastal biodiversity: the Eastern Africa Marine Ecoregion and the Western Indian Ocean Marine Ecoregion (WWF EAME, 2004). The region has a coastal population of over 30 million people who are among some of the poorest in the world and whose livelihoods are largely dependent on marine and coastal resources such as inshore fisheries and mangroves.

Historical records indicate that dugongs were abundant in the coastal waters throughout eastern Africa. However, recent investigations show that dugongs have declined dramatically in recent decades, especially during the 1970s and 1980s. In 2001, in recognition of the need for effective management of dugongs in the western Indian Ocean, Decision CP.3/4 of the third Conference of Parties of the Nairobi Convention, requested regional and international organisations to facilitate the development of a regional initiative to protect the dugong. Consequently, UNEP through the Nairobi Convention, with assistance from WWF and IUCN, provided support for countries of the region, i.e. Kenya, Tanzania, Mozambique, Seychelles, Mayotte, Comoros and Madagascar, to carry out a rapid assessment of the status, distribution and threats to dugongs.

Methods included reviews of existing literature, questionnaire interview surveys, opportunistic sightings and dedicated sighting surveys. Consultation with researchers, conservation practitioners and other relevant contacts in each country was undertaken. Interviews were conducted with fishers, government personnel, diving and aircraft operators in each country of the region. These interview surveys were conducted from June to December 2003. Dedicated aerial surveys were only conducted in Mozambique, especially in Maputo Bay (between 1992 and 2001), Bazaruto Bay and neighbouring areas (1990, 1992, 1995, 1999, 2001 and 2002) and Inhambane Bay (October 1994) and more recently, dedicated aerial surveys have been conducted around the

island of Mayotte from July to November 2005 and in Tanzania in early 2006 (WWF EAME, 2004; Kiszka *et al.*, 2007).

Results indicate that dugongs still occur, but in very low numbers which may not be viable. The most important population seems to be around the Bazaruto archipelago in Mozambique, with a population of at least 100 animals. Dugongs also occur in Tanzania (especially in the Rufiji Delta area), Kenya, Madagascar (along the west and north-east coasts), Mohéli Island (Comoros), in the lagoon of Mayotte (< 10 individuals) and in the Aldabra atoll, Seychelles (at least 4 individuals). Several observations suggest that breeding still occurs, such as in Tanzania (3 calves caught in gillnets in the Rufiji /Mafia area since 2004) and Mayotte (live mother-calf pairs observed during aerial surveys in 2005; Kiszka *et al.*, 2007).

In the past when dugongs were more abundant in the region, they were often deliberately hunted for their meat (a prized source of protein), oil and bones. Today, with populations severely depleted, captures are mostly incidental, although the value of the meat remains an incentive to kill a live dugong caught in a net. Entanglement in legal inshore artisanal set or drift gillnets currently poses the greatest threat to dugongs in the region. Large mesh nets of 12-18 inches are the most threatening fishing gear. In all countries, the decline in dugong populations appears to be related to the introduction and increased use of nylon filament gillnets (WWF EAME, 2004). The shallow, near-shore habitat requirements of dugongs and their slow rate of reproduction render them particularly vulnerable to human activities, including artisanal inshore fishing, habitat disturbance and hunting, and general pressures from a rapidly growing coastal population. Reducing mortality levels is a major challenge, particularly in low income nations and in areas where populations are so small and fragmented. Seagrasses, which comprise the main diet of dugongs, are sensitive plants, prone to human impacts both directly (trawling, mining) and indirectly (inland and coastal clearing inducing erosion and sedimentation, and pollution by heavy metals and organic pollutants). On the Zanzibar Island of Unguja in Tanzania, rapid and unplanned coastal development, primarily for resorts, is causing severe erosion which in turn can have a serious impact on seagrass beds. Near-shore licensed prawn trawling in Kenya, Tanzania and Mozambique in areas where dugongs are most commonly seen is impacting seagrass beds and therefore their foraging areas. Seagrass is also susceptible to large-scale impacts by natural physical processes such as cyclones which occur seasonally in Mozambique and Madagascar. Although dugongs are protected by national legislation in all the east African countries, enforcement of these laws is wanting. The capacity of mandated government agencies responsible for enforcement of such laws is often lacking, with efforts hampered by limited personnel and lack of resources.

Dugong populations are now small and isolated from one another. Several dugong initiatives have since been undertaken in some countries in eastern Africa including aerial surveys in Mozambique, Tanzania and Mayotte and comprehensive interview surveys in Tanzania and the Comoros archipelago (especially in Mohéli). A regional Indian Ocean South-East Asia dugong Memorandum of Understanding on their conservation has also been drawn up and in November 2006, a regional workshop was convened in Mayotte on Incidental Catches of Non Targeted Marine Species in the Western Indian Ocean highlighting ways to mitigate the threat to endangered marine species, including dugongs, from incidental net captures (Kiszka & Muir, 2007).
The most effective short-term conservation measure will be reducing the threat from incidental net captures through restriction or banning of threatening fishing gear (particularly gillnets) and the provision of alternative gear or livelihoods. In the medium to long-term, education, training of local communities and relevant government bodies and the establishment of community-managed dugong sanctuaries will also play a valuable role. Regional cooperation is imperative to coordinate efforts, target resources and encourage the development of a more robust scientific approach. Furthermore, collaborative scientific investigations are needed to provide accurate data on the status, distribution, abundance and ecology of dugongs in the region. In the western Indian Ocean region, very few dedicated surveys have provided accurate estimates of dugong abundance. In many areas, dugong habitats need to be identified. As an example, along the west coast of Madagascar, large seagrass

areas have never been explored and may represent key areas for dugongs in the region. Regional projects are now under consideration to contribute to the recovery of dugongs in eastern Africa. **-Catharine Muir[1] and Jeremy Kiszka[2, 3, *] (**[1] Sea Sense, P O Box 105044, Dar es Salaam, Tanzania; [2] CRELA (Centre de Recherche sur les Ecosystèmes Littoraux Anthropisés), UMR 6217, CNRS-IFREMER-Université de La Rochelle, Avenue Michel Crépeau, F-17071, La Rochelle, France. * Email: jeremy.kiszka@wanadoo.fr; [3] Direction de l'Environnement et du Développement Durable, Collectivité Départementale de Mayotte. BP 101 F-97600 Mamoudzou, Mayotte)

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INDONESIA

New initiative to develop a National Dugong Conservation Strategy and Action Plan for Indonesia.

Recently a new initiative was announced to develop a National Dugong Conservation Strategy and Action Plan for Indonesia. After the publication of the Global Status Report and Action Plans for countries and territories in its range (Marsh et al, 2002), several initiatives have been taken to develop more detailed National Dugong Conservation Strategies. The best known example to date in SE Asia is the Strategy document produced by WWF Philippines during a three-day seminar and workshop held in Davao City from 6-8 November 1998 which marked a pivotal phase in the history of dugong conservation in the Philippines.

In Indonesia little scientific information is available on the abundance, distribution and behaviour of dugongs. The size of dugong populations is unknown (Marsh et al., 2002). In the 1970s the dugong population was estimated to be around 10,000. In 1994, the population was estimated to be around 1,000. Both population estimates are guesses and should not be considered as evidence for a decline in the intervening period, although studies have indicated a dramatic decline in numbers in specific areas such as the Aru Islands (De Iongh, 1996; De Iongh et al, in press). Dugongs have been reported from Balikpapan Bay and suitable dugong habitats have been identified in other parts of the East Kalimantan coastal area (Marsh et al., 2002).

The main objective of this programme is to use the available scientific data on dugong distribution and ecology in Indonesia to draft a National Dugong Conservation Strategy and Action Plan for the remaining dugong populations in Indonesia and to initiate its implementation. The programme will have a high degree of stakeholder participation and the expected output (the strategy) is considered as important as the process to reach this output. This programme is proposed for implementation under the umbrella of the UNEP Regional Seas Programme and the UNEP Convention on Migratory Species (CMS) with Indonesian-Dutch collaboration. For the development of the strategy a phased approach will be followed, covering at least 2007 and 2008. Additional objectives of the proposed programme are defined as follows:

1) Identification of the most recent conservation status of dugong populations in Indonesia, including an update of the main dugong distribution and population size.
2) Identification of available seagrass habitat and associated dugong grazing swards, to estimate maximum sustained population size.
3) Identification of the main threats to dugong survival.
4) Definition of strategic objectives and priority actions for dugong conservation and management.

The Global Status report and Action Plans for countries and territories in the dugongs range as published by Marsh et al. (2002) will be used as a background document. Linkages will be made with other initiatives in the region, notably the Australian sponsored initiative to develop a Memorandum of Understanding under CMS on the conservation and management of dugongs and their habitats throughout their range and an associated conservation and management plan. Consistency and cross-referencing with the provisions of this instrument, currently in its final stage of negotiation, will be searched to the fullest extent possible. Other National Dugong Conservation Strategies (e.g. Philippines) will also be considered. The dugong is considered to be a flagship species for coastal conservation efforts in the region, including environmental education and raising awareness. Coastal areas throughout Asia are threatened by habitat destruction through unsustainable fishing practices (dynamiting, the use of cyanide), while inshore seagrass meadows are impacted by land based activities resulting in excessive sedimentation. The Research Centre of Oceanography in Jakarta and the Institute of Environmental Sciences in Leiden have signed a Memorandum of Understanding (MOU) for the development of the National Dugong Conservation Strategy and Action Plan for Indonesia.

Under this MOU a Joint Steering Committee has been established, which gives guidance and technical advice to the coordinators of the project. The Director of the Research Centre of Oceanography in Jakarta chairs the Steering Committee and members have been selected during the first months of the project, based on expertise in a relevant field, for development of the National Dugong Conservation Strategy and Action Plan.

Expatriate (CML Leiden, The Netherlands) and Indonesian researchers (i.e. Research Centre for Oceanography in Jakarta), institutions (i.e. Ministry of Marine Affairs and Ministry of Environment in Jakarta), students (i.e. UNMUL in Samarinda, UNHAS in Makassar), and national and local NGO's will work together to develop the National Dugong Conservation Strategy and Action Plan for Indonesia during 2007 and 2008. The anticipated outputs at the end of 2008 will be a first draft of the plan, including an identification of major gaps in information. It is also the intention to implement additional aerial and/or ground surveys to update our knowledge of dugong distribution during 2007 and 2008, if additional funds are found. In addition, stakeholder workshops will be organised and a communication plan will be set in place if additional fundraising is successful.

Ground surveys, aerial surveys and interviews with local fishermen conducted during 1990 to 2005 have already revealed the presence of dugongs in the coastal waters of Maluku Province, Java island, Bali island, lesser Sunda islands, Sulawesi, East Kalimantan and West Papua. Dugongs in Indonesia depend to a large degree on intertidal seagrass meadows situated on the narrow coastal shelf. Most of these meadows were situated in front of coastal villages. Field observations, the use of satellite telemetry and interviews with local villagers showed that most of the dugongs investigated consistently foraged on a limited number of two to three "core areas" (De Iongh et. al., 1998; De Iongh et al., in press). Rotational grazing in grazing swards is a common phenomenon by small feeding assemblages and individual dugongs returned to the same feeding plots at regular intervals of time. These feeding strategies will have to be taken into account when designing protected areas and community based conservation schemes for the remaining dugong populations in Indonesia (Harkes, 1998). The coordinators hope to report on a regular basis in SIRENEWS on the progress of this important initiative. -**Hans de Iongh and Wawan Kiswara** (DeIongh@cs.com)

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MEXICO

Manatees at freshwater systems in Southeastern Mexico. *Research:* Manatees in Mexico had been mostly studied along the Caribbean coasts of the country, within estuarine systems (Morales-Vela and Olivera-Gómez, 1997; Morales-Vela et al., 2000). This is because it is relatively easy to conduct aerial or boat surveys and to capture manatees for radio tagging, health assessments or genetic sampling. However, populations of manatees at freshwater systems associated with major rivers flowing into the Gulf of México, for example Usumacinta and Grijalva (whose joint runoff is more than 30% of the total in Mexico), in the Mexican states of Tabasco, Chiapas and Campeche, seems to be larger than those of the Caribbean coasts (Colmenero and Hoz, 1986). Previous studies (Alvarez, et al., 1986; Colmenero and Hoz, 1986; Arriaga-Weiss and Contreras-Sánchez, 1993) showed that manatees are frequently sighted all along the waterways and lake systems connected with the Usumacinta and Grijalva rivers, which serve as main dispersal corridors for manatees.

A research program was initiated in 2005 in the Mexican state of Tabasco to provide a technical base for studying and managing the manatee populations in the region, motivated by threats like stranding and mortality of free ranging and captive manatees, cases of orphaned calves, illegal hunting and general habitat deterioration. Interviews with local people and fishermen, as well as navigation along rivers, channels and lakes, showed that manatees are well distributed throughout the region, including the areas with extended lake systems where manatees are most frequently sighted. Almost all local people interviewed correctly identified and described manatees and had experienced encounters with them. In addition to visual examination of water courses in search of manatees, we tested and evaluated a side scan sonar system, which had been proven to detect manatees as far as 70 feet from each side of the boat.

In 2006 we made the first attempt to capture and radio tag manatees within freshwater systems of Mexico. After some trials we developed a successful method for capturing manatees in this habitat. We encircled manatees in large nets and waited until the manatees tried to escape by pushing the net with their head. At that point the bottom of the net was pulled up, entangling the manatees in the net. The manatees were then restrained at one side of the boat for a few minutes until field personnel were prepared to pull the animal into the boat. The manatees suffered some superficial scrapes, however the entire procedure only lasted approximately 10 minutes with minimal struggling from the animal. We used VHF tags similar to those developed by Sirenia Project in Florida, USA, and implanted AVID pit tags for identification. Blood samples

were taken from each animal at the brachial vascular bundle (Dierauf and Gulland, 2001). Before releasing the manatees back into the water a fluke skin sample was gathered for genetic analyses.

With this procedure, from April 2006 to August 2007 we captured and radio tagged 13 manatees in the region. Eight were tagged in "Laguna de Las Ilusiones", an isolated urban lake in the urban area of the capital city of the state of Tabasco, and five at the southeastern zone of the state, four in the lake of "La Barbona" in the lake system of Leona Vicario and one at Arroyo San Pedro, a stream which drains to the Usumacinta river. Results from blood samples show that the manatees were healthy when captured. We are evaluating their movements.

Conservation

Hunting is rare in the region, but when caught in nets manatees are sometimes killed and used for meat. However, other factors are causing more concern, such as natural or artificial closing of lake systems where manatees become isolated and where interbreeding, temporal food deprivation and high temperatures result in health problems within these isolated populations. Opening areas for agriculture and poultry changed more than 85 % of the original landscape in the last 50 years in the region and has caused sedimentation, eutrophication, and pollution in the lake and river systems.

In addition to these problems, part of the region is one of the most important land areas for oil and gas extraction in Mexico, and their daily and temporal activities could cause injuries to animals, such as transportation of personnel (in fast boats) and machines and products (in large cargo boats). There is also a latent danger for manatees in the case of explosions or spills of gas and oil pipes. Manatees in captivity is another concern. There are two parks with captive manatees kept in freshwater ponds where the only management procedure is feeding, except when the animals get sick. Besides these two parks, there are other areas were isolated manatees are kept and were management procedures should be implemented.

In late 2006 and early 2007, six workshops were conducted with children in the first and second grade of the primary school in communities located north of the study area, within a protected natural area (The Biosphere Reserve of Pantanos de Centla). The aim of these workshops was to evaluate if children recognize the manatee and to teach them basic facts about manatees, their importance, and activities that threaten manatee conservation in the area. Interchange of information with the children was very useful, for example, some kids said they had eaten manatee meat recently!

The area is an important hotspot for conservation of Antillean manatees due to their extent and numbers, so research and environmental education must continue in order to ensure the survival of this species in the long term. - **León David Olivera-Gómez** (División Académica de Ciencias Biológicas, Universidad Juárez Autónoma de Tabasco. carretera Villahermosa-Cárdenas Km. 0.5, S/N, C.P. 86150. Villahermosa, Tabasco, México. E-mail: leon.olivera@dacbiol.ujat.mx)

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SIERRA LEONE

The distribution and exploitation of manatees in Sierra Leone: survey report. The following text is the summary of a report contributed to the management plan for West African Manatee (*Trichechus senegalensis*) population conservation. For the entire report (in French), please contact the authors.

From 3-22 October 2006, we gathered information about the manatee's population from fishing communities situated along the littoral coast of Sierra Leone and its three main estuaries. As a continuation of the survey methodology used by Reeves in 1986 (Reeves *et al*, 1988), information was collected regarding 1) the presence and distribution of manatees along the littoral coast, 2) the ecology, biology and manatee behaviour, 3) the local perception about manatees and 4) the types of exploitation. Based on 20 interviews discussing the local knowledge of manatees in the 18 villages investigated, we determined that:

1. The manatee appears to be widely distributed in the major rivers and estuaries of Sierra Leone.
2. Some villagers know precisely the ecological and/or biological behaviour of the manatee.
3. Manatees are mostly considered by the local villagers as a food resource and a destructive animal.
4. Manatees are killed by occasional captures using classic fishing methods and by specific captures using specially-designed traps and in a special large-mesh net set.

In order to contribute to the management plan for West African manatee population conservation in Sierra Leone currently coordinated by Wetlands International, our recommendations following this preliminary study are divided in three main categories:

1. The need for improvement of scientific knowledge of the West African manatee and additional information on the types of exploitation in Sierra Leone.
2. Educating the authorities and the local communities on the value of the manatee and the need to protect the manatee.
3. The creation of sanctuaries and protected areas.

This project was carried out in partnership by Noé conservation, FIBA and the Ministry of Fisheries of Sierra Leone and received financial support from the Fondation TOTAL pour la biodiversité et la Mer. -**Antoine Cadi and Jean-Marie Ballouard** (Noé Conservation Association, tel : 00 33 615 77 511 67, www.noeconservation.org, acadi@noeconservation.org, jeanmarieballouard@hotmail.com)

ABSTRACTS

THE SPATIAL ECOLOGY OF DUGONGS: APPLICATIONS TO CONSERVATION MANAGEMENT
PhD Thesis submitted by James Sheppard

ABSTRACT

Dugongs are large primary consumers of seagrass communities, and thereby shape the diversity, structure, and dynamics of these extensive ecosystems. The dugong is listed as vulnerable to extinction at a global scale. Because dugongs are seagrass specialists, understanding the interaction between dugongs and their seagrass habitats is crucial to their conservation. Habitat use by dugongs is beginning to receive greater attention by managers and ecologists, but a spatially-explicit model capable of predicting usage by dugongs based on attributes of those habitats is lacking. Studying the interaction between dugongs and their seagrass food requires knowledge of the movements and diving behaviour of dugongs at scales relevant to both dugongs and managers. Information is needed on dugong spatial patterns, including movement behaviours and habitat use, across domains of scale. Multi-scale approaches to dugong research have not been possible in the past because of the difficulties in observing dugongs directly and the low resolution of telemetric equipment.

My project capitalised on recent technology incorporating accurate GPS technology into tracking equipment to monitor the habitat use of wild animals at very high resolution (<10 m). Advances in geographic information systems (GIS) and spatial modeling enabled habitat selection by satellite-tracked dugongs to be analysed in a high-resolution, spatially explicit manner. I used hierarchical scales of spatial analyses to assess the relative importance of different seagrass meadows and parts of meadows to dugongs at scales that are suitable for informing policy concerning the management of human activities. My central research hypotheses were that: (1) dugongs forage like terrestrial mammalian grazers in that they prefer habitats where their foraging efficiency is greatest and (2) patterns of dugong movements and habitat use across spatial scales are intimately linked to the availability and distribution of quality seagrass forage.

I investigated the mechanisms that produce the large-scale distribution and movement patterns of dugongs by reanalysing the results of historical aerial surveys and satellite tracking conducted by earlier researchers in combination with new data from my GPS telemetry of 20 dugongs in sub-tropical and tropical waters of Queensland and the Northern Territory, Australia. The mean patch size supporting high relative density (> 0.1 dugongs/km^2) of dugongs over 20 years along the urban coast of Queensland was 77 km^2 (± 4 s.e.). Hence, at regional and landscape scales (> 100 km^2) dugongs select habitat at the level of individual bays along the coast. The tracked dugongs were followed for periods ranging from 15 to 551 days and exhibited a large range of individualistic movement behaviours; 26 individuals were relatively sedentary (moving < 15 km) while 44 made large-scale movements (> 15 km) of up to 560 km from their capture sites. Male and female animals, including cows with calves, undertook large-scale movements (LSM; > 15 km).

At least some of these movements were return movements to the capture location, suggesting that such movements were ranging rather than dispersal movements. Large-scale movements included macro-scale regional movements (> 100 km) and meso-scale inter-patch local movements (15 ≤ 100 km) and were qualitatively different from tidally-driven micro-scale commuting movements between and within seagrass beds (< 15 km). Large-scale movements were rapid and apparently directed. Tracked dugongs rarely traveled far from the coast (mean max distance = 12.8 ± s.e. 1.3 km). Dive profiles from the time-depth recorders suggest that dugongs make repeated deep dives while traveling rather than remaining at the surface. Some animals caught in the high latitude limits of the dugongs' range on the Australian east coast in winter apparently undertook long distance movements in response to low water temperatures, similar to the seasonal movements of Florida manatees.

A 24 km^2 seagrass meadow in Hervey Bay, Queensland, Australia was confirmed as important dugong habitat on the basis of the tracking data. Marine videography, Near-infrared Spectroscopy (NIRS) and Geographic Information Systems (GIS) were used to survey, analyse and map seagrass species composition, nutrient profile and patch structure of the meadow at high resolution (200 m). Five species of seagrass covered 91 % of the total habitat area. The total above and below-ground seagrass biomass was estimated to be 222.7 ± s.e. 19.6 t dry-weight. *Halodule uninervis* dominated the pasture (81.8 %, 162.2 t), followed by *Halophila ovalis* (35.3 %, 16.5 t), *Zostera capricorni* (15.9 %, 22.2 t), *Halophila spinulosa* (14.5 %, 21.9 t), and traces of *Halodule pinifolia*. Because the distributions of the various seagrass species overlapped, their combined percentage totaled > 100 % of the survey area. The seagrass formed a continuous meadow of varying density.

For all seagrass species, the above-ground component (shoots and leaves) possessed greater total nitrogen than the below-ground component (roots and rhizomes), which possessed greater total starch. Because of the relatively low intraspecific variation in nutrient composition, nutrients were concentrated according to seagrass biomass density. *H. uninervis* was the most nutritious seagrass species because of its higher whole-plant nitrogen (1.28 ± s.e. 0.05 % DW) and starch (6.42 ± s.e. 0.50 DW %) content. *H. uninervis* formed large, clustered patches of dense biomass across the pasture and thus nitrogen and starch were concentrated where *H. uninervis*

was prevalent. These survey and analytical techniques enabled me to rapidly, economically and accurately quantify and characterise seagrass habitat at scales relevant to a large forager.

I used GIS and spatial statistics to identify the role of physical environmental characteristics in determining the activity patterns and fine-scale space-use of dugongs tracked in coastal and deepwater seagrass habitats using GPS telemetry. A seagrass meadow was defined as a core dugong habitat if more than 10 days of satellite location fixes were obtained from an individual animal occupying an area <100 km^2. Habitats were categorised as inshore/intertidal or offshore/subtidal depending on their distance to the shore and the water depth. Inshore/intertidal habitats had a shallow component that was exposed at low-tide. Offshore/subtidal habitats were at least 5 km from the nearest mainland and were at least 3 m deep at mean low water spring tide (MLWS). Location fixes acquired from dugongs tracked in coastal habitats exhibited significant circadian rhythms, with fewer locations during the morning than during late afternoon/night. GPS location fixes could only be acquired when the transmitter was at the surface. Such periods are typically brief, as when the animal surfaces to breathe. More GPS locations were acquired from inshore/intertidal dugongs that were foraging in the intertidal zone than from animals in the subtidal zone. This telemetric artefact provided an indication of when the animals were moving across shallow intertidal waters. More locations were received at night when the animals were generally closest to the shore and in shallow water and fewer locations were received during the day when animals were further subtidal in deeper waters. Hence, the average depth of water experienced by dugongs and their distances from the shore may have been significantly underestimated, especially when fix success was low, since animals that were in shallower water were more likely to be sampled. Consequently, my estimates of the diel patterns of dugong space use were more conservative than the actual situation and probably underestimated the strength of the tidal patterns.

Dugongs were in deeper water more often during the morning than during late afternoon/night. There was no effect of tide height on the actual depths in which dugongs occurred. Dugongs in coastal habitats were furthest from the shore between 6:00am and 12:00pm and closest between 3:00pm and 12:00am. Dugongs were closer to the shore during high tide than during low tide. Physical environment variables had little or no effect on the spatial patterns of dugongs tracked in deep water. The movement speeds of the coastal and deepwater dugongs increased marginally between 9:00am and 3:00pm, from an average of 200 to 300 m/hr.

Seven dugongs were GPS tracked at a fine spatial scale (< 10m) within the Burrum seagrass habitat in winter. Resource selection within the habitat was modelled by comparing the dugongs' use of space with the distribution of their seagrass food resources within an area defined using the combined space-use of the tracked animals. The association of dugongs with seagrass quantity (biomass) and quality (nutrients) was analysed within six time/tide combinations to examine the influences of tidal periodicity and the diel cycle on resource selection. I used resource utilisation functions (RUFs) to relate a probabilistic measure of each individual dugong's space-use in each time/tide combination in a utilisation distribution (UD) (dependent variable) to the spatial landscapes of the resource variables (independent variables) using multiple regression.

The RUF models indicated that dugong space-use was consistently centred over seagrass patches with high nitrogen concentrations, except during the day at low tides when their space-use was centred over high seagrass biomass and away from seagrass with high starch concentration. Dugong association with seagrass high in starch was positive during both day and night high tides when dugongs could access intertidal areas where the seagrass biomass was generally low. Patterns of association with seagrass species were less definite. Estimates of the intensity of dugong space-use in relation to available seagrass resources may be confounded by the differentiation of fix probability by depth and speed. Because my estimates of dugong space-use in relation to subtidal seagrass may have been more conservative than the data suggested, the positive association of dugongs with patches of high biomass seagrass and avoidance of patches containing *H. spinulosa* and *Z. capricorni* in the subtidal zone may have been over-estimated by this sampling bias.

I posit that dugong habitat selection and resource use occur hierarchically, across (at least) three different domains of scale: (1)at a regional-scale (> 10 000 km^2) dugongs select habitat at the level of individual bays along the Queensland coast; (2) at a landscape-scale (< 10 000 km^2), dugongs select seagrass pastures within bays along the Queensland coast comprised of nutritious plant species; (3) at a local-scale (< 10 km^2) within seagrass pastures that are within bays along the Queensland coast, dugongs select seagrass patches on the basis of their nutrient concentrations. I recommend that the appropriate scales at which to manage dugong populations and their seagrass habitats be co-ordinated within and across the hierarchical scales of habitat use indicated by my analysis.

My finding that dugongs frequently undertake large-scale moves has implications for management at a range of scales, and strengthens the aerial survey and genetic evidence for management and monitoring at ecological scales that cross jurisdictions. The capacity of large-scale monitoring programs to detect trends in dugong numbers at scales of even thousands of km^2 is confounded by the dugongs' tendency to undertake large-scale moves. With movement between bays a common occurrence, estimates of population size and trends can only be meaningfully made at regional scales.

The tendency for dugongs to track the bottom on large-scale movements may increase their vulnerability to incidental capture in bottom set gill nets. In addition, if dugongs transfer their spatial knowledge of the location of quality food resource patches to their offspring, then local depletions will lead to loss of this knowledge. Areas of high quality seagrass may thus become unknown to

dugongs. In the absence of grazing pressure such areas may become less valuable as dugong habitat if the early seral stage species of seagrass preferred by dugongs convert to more fibrous species.

My research suggests that dugongs actively select seagrass habitats comprised primarily of *H. ovalis* and *H. uninervis*, based on the high starch and nitrogen content of these species. Bays containing these quality food resources comprise an interlinked network of core habitats between which dugongs frequently move. Accordingly, bays along the Queensland coast with seagrass meadows dominated by *H. ovalis* and *H. uninervis* should be afforded a high level of protection as potential quality dugong habitat. Bays with extensive intertidal meadows of *H. uninervis* should also receive enhanced protection, even if the seagrass biomass is low. Even though they have low seagrass biomass, thermoregulatory habitats play an important role in maintaining dugong populations and should be included in dugong habitat protection strategies.

CONFLICT TO CO-MANAGEMENT: EATING OUR WORDS TOWARDS SOCIALLY JUST CONSERVATION OF GREEN TURTLES AND DUGONGS IN THE GREAT BARRIER REEF, AUSTRALIA
PhD Thesis Submitted by Melissa Nursey-Bray

ABSTRACT

Indigenous communities worldwide face multiple challenges to maintain their unique cultural identity and value systems. In the natural resource management arena, these challenges include the imposition of western solutions to environmental management and biodiversity protection. This imposition has caused the dispossession or relocation of Indigenous peoples from their lands, a loss of traditional ecological knowledge, social disempowerment and economic inequity.

Indigenous peoples are responding to these challenges by asserting their cultural identity, developing cultural re-vitalisation programs, and actively participating in western political processes for ongoing involvement in the environmental and natural resource management domain. Nonetheless, to date, many of these programs are faltering or have failed in their long-term implementation.

Using a case study approach, my thesis examines this issue through an examination of Indigenous hunting of threatened species in a protected area. My research is based on the contention that language matters, as it is an enabling tool which reveals the knowledge and power relations in natural resource management. To this end, I compare perspectives held by Indigenous people on the one hand and government Management Agencies on the other, about traditional hunting, planning and the management of Green turtles (*Chelonia mydas)* and Dugongs (*Dugon dugon)* in Australia's Great Barrier Reef World Heritage Area (GBRWHA). To compare these perspectives I used a combination of discourse analysis, historical analysis and participant observation to analyse the development, implementation and subsequent failure of the Hope Vale Turtle and Dugong Hunting Management Plan, 'Guugu Yimmithirr Bama Wii: Ngawiya and Girrbithi'.

My research yielded four key findings: (i) that significant differences exist between Management Agencies and Hope Vale Community about hunting, planning and management (Management Agency discourse for example prioritised biodiversity protection, while Indigenous discourse was primarily about ensuring cultural survival); (ii) that language in resource management does matter because different linguistic interpretations within such programs have a direct impact on their efficacy (iii) that social justice dimensions must be incorporated within management regimes in order to achieve both cultural survival and biodiversity protection objectives; and (iv) that resource management initiatives can never be divorced from the impact of external events, actors and power regimes.

I thus confirm my *thesis* or argument that the use and understandings of language in resource management reflect power and knowledge relations, which in turn influence and impact upon the effectiveness of natural resource management programs.

Through the integration of these findings my thesis concludes with the presentation of a socially just conservation methodology to guide future collaborations between Indigenous peoples and Management Agencies when addressing the ongoing cultural harvest of wildlife (such as Green turtles and Dugongs) in protected areas.

LONG-DISTANCE OCEANIC MOVEMENT OF A SOLITARY DUGONG (*Dugong dugon*) to the COCOS (KEELING) ISLANDS.

Hobbs, J-P.A.*, A.J. Frisch, J. Hender, and J.J. Gilligan. 2007. *Aquatic Mammals* 33(2):175-178. *Australian Research Council Centre of Excellence for Coral Reef Studies, and School of Marine and Tropical Biology, James Cook University, Townsville, Queensland, 4811, Australia; E-mail: Jean-Paul.Hobbs@jcu.edu.au

In this paper, we report on the arrival of a small (2 m long) male dugong (*Dugong dugon*) to the Cocos (Keeling) Islands (12° 12' S, 96° 54' E), Indian Ocean. The dugong arrived in June 2002 after traveling more than 1,000 km across deep open ocean, during which time it would have been vulnerable to predation and presumably unable to feed. This is the longest recorded dugong movement and demonstrates that dugongs have the capacity to make long-distance oceanic movements to colonise distant, unoccupied locations.

The solitary dugong has remained at the Cocos Islands for at least four years and exhibits unusual habitat use and behaviour; it frequently occupies deep water on the edge of the coral reef and interacts with SCUBA divers.

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