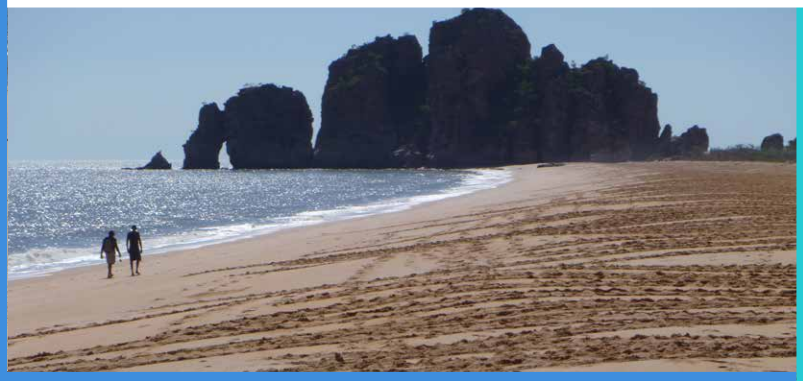
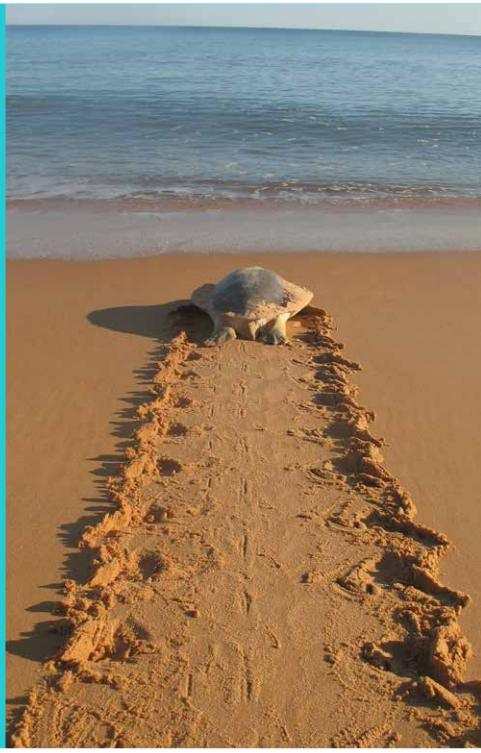
Proceedings of the
Second Australian and Second Western Australian

# Marine Turtle Symposia
# Perth 25-27 August 2014





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Front cover photos, clockwise: Rehabilitated loggerhead turtle release (photo – Dani Rob/Parks and Wildlife); Cape Domett (photo – Tony Tucker/Parks and Wildlife); flatback returning to the water (photo – Andrea Whiting); flatback hatchling (photo – Parks and Wildlife); loggerhead turtle eggs (photo – Scott Whiting/Parks and Wildlife) and loggerhead turtles fitted with satellite trackers (photo – Dani Rob/Parks and Wildlife).

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Second Australian and Second Western Australian

# Marine Turtle Symposia
# Perth 25-27 August 2014

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We would like to thank all sponsors for making this event possible. The funds contributed by the sponsors meant low fees for the delegates and enabled the production of the proceedings.

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# Preface

In 2014, the Australian and Western Australian Marine Turtle symposia were combined and held as one event at Hillarys in Perth, Western Australia.

The Australian Marine Turtle Symposium had its inaugural meeting in Buderim in Queensland in 2012 with the objectives of bringing together people and projects from across Australia and to bridge gaps between local meetings and the annual International Sea Turtle Symposia. Given the size of Australia and the breadth and depth of projects by a variety of stakeholders a biennial meeting seemed appropriate.

The first Western Australian Marine Turtle Symposium was held in Perth in 2012 with the aim of bringing people and stakeholders together. In Western Australia, the last decade has seen may new stakeholders develop new projects and a biennial symposium provided a mechanism to bring people and ideas together with the intent on forming collaborations and discussing current issues.

The 2014 combined symposium hosted a total of 59 ten minute oral presentations held over two days. On the third day there was a refocus on Western Australia and general themes and short workshops were held to allow people opportunities to mix and share relevant information. After an ice breaker session, informal workshop sessions included: discussion of WA issues and also the future of State and National symposia; oil spill response and WA's stranding program, flipper and satellite tagging, turtle rehabilitation and light impacts.

The three-day event was attended by delegates from all Australian States and Territories plus Thailand and New Caledonia.

| Region | Delegates |
|---|---|
| Western Australia | 80 |
| Queensland | 35 |
| Northern Territory | 20 |
| Victoria | 3 |
| Australian Capital Territory | 3 |
| New South Wales | 1 |
| South Australia | 1 |
| Tasmania | 1 |
| Cocos Keeling Islands | 1 |
| New Caledonia | 1 |
| Thailand | 1 |
| TOTAL | 147 |

# Acknowledgements

This event was enabled by the contributions of many individuals and organisations.

Thank you to the Honorable Albert Jacob MLA, Minister for Environment, for addressing the delegates.

We thank the sponsors for their generous support that made the event possible and lowered the costs for individuals to attend. We thank May Maguire, Noongar Traditional Owner, who conducted the Welcome to Country.

Thank you to Dr Margaret Byrne, Director of Science and Conservation Division, Department of Parks and Wildlife for opening the event.

Thanks to all the presenters for the quality and diversity of presentations.

Thanks to the delegates who created a comfortable and inclusive atmosphere resulting in an interactive event.

Thanks to the organising committee for attending phone link-ups and making early decisions on format and venue.

We thank Corrine Severin for overseeing the general administration including registrations and payments and also Sandy Grose and David Hogg from Parks and Wildlife who facilitated the electronic payments. Thanks to Ryan Douglas who helped with many aspects over the three days including technical assistance and recording the event. The facilities at Ern Halliday were great and Brett Poole and staff made booking and setup easy. Thanks also to Stockbrands who supplied engraved tags for the delegates.

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| Michael Guinea | Charles Darwin University, Casuarina, NT |
| Mark Hamann | James Cook University, Townsville, Qld |
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| Daniel Oades | Kimberley Land Council, Broome, WA |
| Kellie Pendoley | Pendoley Environmental Pty Ltd, Booragoon, WA |
| David Waayers | Imbricata Environmental, West Perth, WA |

# Foreword

## The conservation and effective management of Western Australia's unique and diverse marine environment is a key priority for the Government of Western Australia.

With a coastline of more than 13,500km, Western Australia has marine biodiversity of international significance. Its remarkable wildlife includes whale sharks, humpback whales, snubfin dolphins and six of the world's seven species of marine turtles. The waters of Shark Bay World Heritage area support the world's most extensive seagrass meadows and largest population of dugongs.

Western Australia currently has 16 marine parks and reserves and in the Kimberley region – one of the most pristine areas remaining in the world – the State Government has established new marine parks at Camden Sound and Eighty Mile Beach, with commitments to establish three more marine parks at Horizontal Falls, North Kimberley and Roebuck Bay. All these marine parks will be jointly managed with traditional owners.

Since 2008, the Government's commitment to new marine parks has more than trebled the State's marine reserve system from about 1.5 million hectares to about 5 million hectares, taking the coverage from about 12 per cent to about 30 per cent of WA's coastal waters. Through the *Kimberley Science and Conservation Strategy* the Government has invested $81.5 million to protect the region's unique natural assets.

Western Australia has a strong marine science community that undertakes and facilitates research and monitoring to support the management of marine wildlife and its first-class system of marine parks and reserves. Conservation of marine turtles relies on this strong science base, and community and industry support also play a significant role.

The Department of Parks and Wildlife has a number of long term turtle conservation programs in place that are supported by industry, Aboriginal people and the wider community. Scientists, field staff and volunteers have engaged in marine turtle research for almost 30 years, including the tagging and release of more than 50,000 adult female turtles for population demographic, migration and connectivity studies. Given the highly migratory nature of marine turtles, cross jurisdictional approaches that help us all achieve conservation outcomes are also important.

Symposia such as these, where information and ideas can be shared and discussed, are essential to increasing understanding of marine turtle conservation. These symposia in particular, bring together a wide range of stakeholders from government, industry, community groups, universities, and conservation groups to share knowledge for enhanced conservation outcomes. The Australian Marine Turtle and Western Australian Symposia have made a significant contribution to improving knowledge that assists our efforts to conserve marine turtles.

Hon Albert Jacob MLA
Minister for Environment; Heritage Western Australia
August 2015

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# Abstracts

## Session chairs

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| **Day 1** Session 2 | Ruth Kamrowski (Pendoley Environmental Pty Ltd)<br>Kim Riskas (James Cook University) |
| **Day 1** Session 3 | Michael Guinea (Charles Darwin University)<br>Kiki Dethmers (North Australian Marine Research Alliance) |
| **Day 2** Session 4 | Colin Limpus (Department of Environment and Heritage Protection)<br>Nev McLachlan (Volunteer for Dept. of Environment and Heritage Protection) |
| **Day 2** Session 5 | Kellie Pendoley (Pendoley Environmental Pty Ltd)<br>Catherine Bell (Pendoley Environmental Pty Ltd) |
| **Day 2** Session 6 | Fiona Bartlett (Department of the Environment)<br>Daniel Oades (Kimberley Land Council) |
| **Day 2** Session 7 | David Waayers (Imbricata Environmental)<br>Kelly Howlett (Care for Hedland) |
| **Days 1,2 & 3** Workshop | **Talking Circle – Indigenous Rangers**<br>Daniel Oades (Kimberley Land Council) |
| **Day 3** Ice Breaker | Stuart Field and Tony Tucker (Department of Parks and Wildlife) |
| **Day 3** Workshop | **Oil Spill Response and WA Stranding Program**<br>Stuart Field and Scott Whiting (Department of Parks and Wildlife) |
| **Day 3** Workshop | **Flipper and Satellite Tags**<br>Scott Whiting (Department of Parks and Wildlife) |
| **Day 3** Workshop | **Rehabilitation**<br>Simone Vitali (Perth Zoo)<br>Cameron Craigie (Department of Parks and Wildlife)<br>Rochelle Ferris (James Cook University) |
| **Day 3** Workshop | **Light Impacts**<br>Kellie Pendoley (Pendoley Environment Pty Ltd) |

# Marine Turtle Research and Turtle Sanctuary Update from the Crocodile Islands Rangers

***Warrick J. Angus***

Crocodile Islands Rangers, PMB 122, Winnellie, NT 0822
Presenter - contact: warrick.angus@mopra.org.au

The Crocodile Islands lie about 500km east of Darwin. These islands are remote, mostly untouched and, as their name suggests, are home to lots of crocodiles. However, the islands are also home to lots of turtles. Three islands are listed as sites of national significance for marine turtle nesting. Flatback, green and olive ridley turtles are commonly seen nesting on the beaches, and hawksbill turtles are seen in the waters.

The Traditional Owners are Yolngu, otherwise known as the Saltwater People. Their home estates are the land and seas of the Crocodile Islands, and naturally turtles play a massive role in their lives and culture.

The Crocodile Islands Rangers (CIR) and the community have become increasingly aware of the challenges turtles face throughout the world, and are continually considering their relationship in this cause. The Executive Committee of the CIR (CIREC) has put several initiatives in place to help protect the turtles in this area. The rangers perform regular ghost net and marine debris patrols. The CIREC also want to learn more about the turtles, and so have engaged turtle researcher Kiki Dethmers. Since Kiki has been on board, the rangers have started to gather data on turtle nests and abundance on three islands, and hope to expand this data to include other islands. They are also satellite tracking several turtles and it is interesting to see that one turtle (an olive ridley) has made its way all the way to Enu Island, an island off the south-eastern coast of the Aru Archipelago.

Most importantly, the late Senior Traditional Owner of the Crocodile Islands and 2012 Senior Australian of the Year, Laurie Baymarrwangga, had several visions for her people. One was to create the CIR program, and another was to establish a turtle sanctuary. She used her rangers as a vehicle to educate and inspire the community about creating a turtle sanctuary. In 2012 the rangers had successfully created their own Yolngu law that prevented turtle hunting and egg collection within a nominated sanctuary area around Gurriba Island, for a period of two years.

Final negotiations are now in place to make it a permanent sanctuary. It is hoped that this area will one day be a marine sanctuary, which the rangers can patrol and look after, whilst making it a wildlife refuge and place for all Australians to enjoy.

**Figure 1**. Crocodile Islands Ranger collecting marine debris.

**Figure 2.** Crocodile Islands Ranger removing a ghost net.

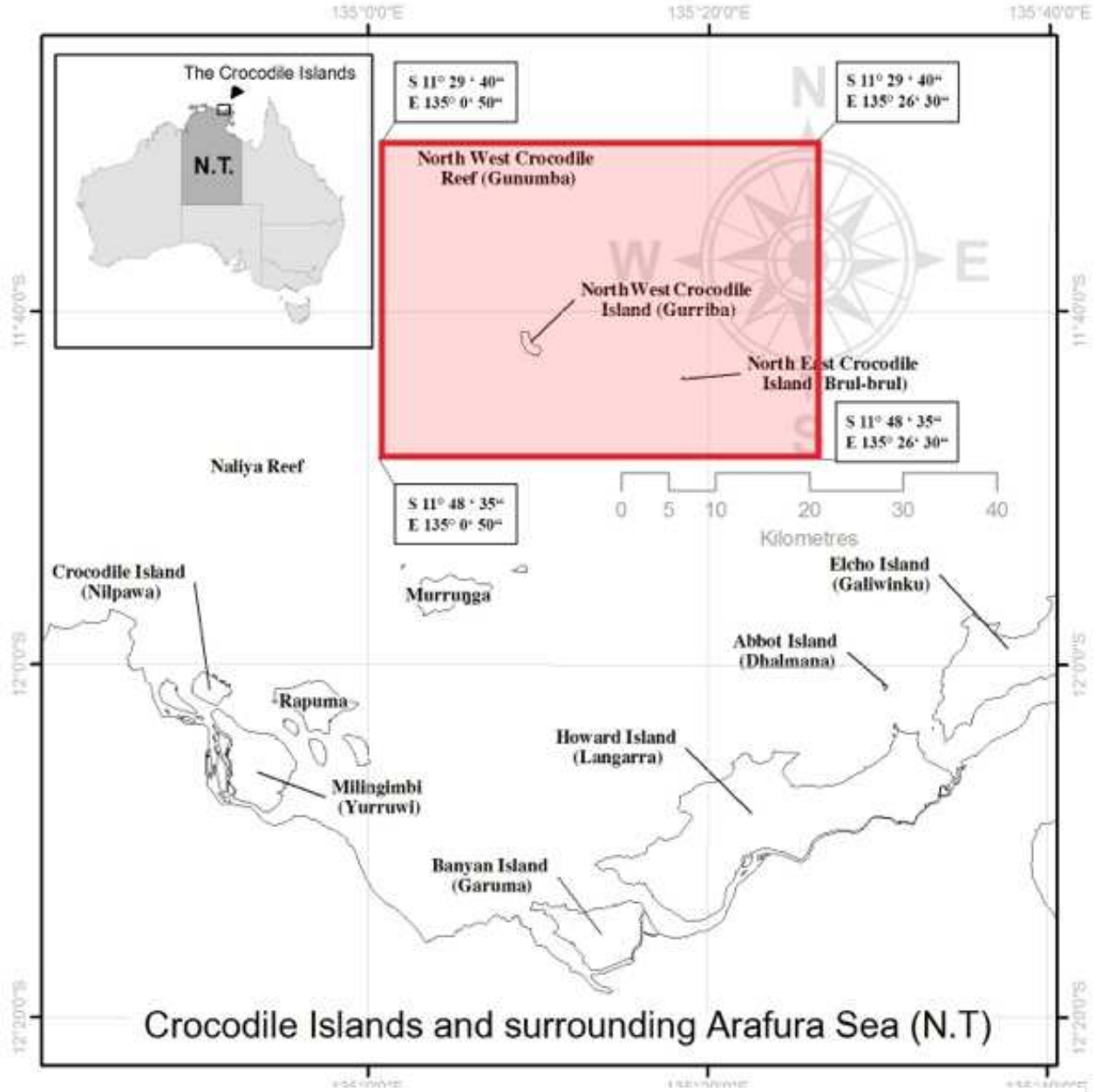


**Figure 3**. The location of the Crocodile Islands Turtle Sanctuary.

# Dressed for Success: an Outline of HSE Requirements for Turtle Monitoring in the Resource Industry

***Patrick M. Becker***

Pendoley Environmental Pty Ltd., 12A Pitt Way, Booragoon, WA 6154
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The health and safety of employees is paramount to the successful execution of field research. The resource industry has high expectations of contractors with regard to safe systems of work, from the thorough identification of hazards to the development, detailed documentation and implementation of control measures and management of resultant records.

When conducting field work on large industry projects it is common for Company to adopt a single HSE (Health and Safety Equipment) standard to which all contractors must comply, regardless of relative risk levels. In this presentation we will:

- Investigate some of the hazards identified from our fieldwork and the controls employed by Pendoley Environmental to minimise the risk to as low as reasonably practical, with a particular emphasis placed on personal protective equipment (PPE);
- Examine the type and reasoning behind the sort of personal protective equipment that is used in different disciplines of field work, and issues such as the cost of reducing one hazard at the expense of another; and
- Examine the drawbacks of the 'Management by Exception' approach commonly adopted by industry and not always applicable to environmental field work.

# Patterns and Pathways: Marine Construction and Patterns of Dispersal in Hatchling Flatback Turtles at Barrow Island

***Catherine Bell[1], Dorian Moro[2] and Kellie Pendoley[1]***

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Barrow Island, Western Australia, is a Class A nature reserve and the location of the Chevron-operated Gorgon Project, Australia's largest single resource development. The Island's east coast supports a regionally substantial flatback turtle (*Natator depressus*) rookery of ca. 1800 individuals nesting annually. Available nesting habitat comprises six primary beaches, two north and four south of the marine construction footprint. On completion, a materials offloading facility (MOF) including a solid causeway and associated jetty will extend more than four km perpendicular to shore. Daytime hatchling dispersal (travel speed and bearing), behaviour and survival in the near-shore ≤ 2 km environment were assessed during the 2009/10 (pre-marine project construction) and 2011/12 (during marine construction) flatback turtle reproductive seasons. Hatchlings were tracked during daytime hours due to health and safety issues associated with tracking at night in the presence of a busy offshore marine fleet. Hatchlings marked with light plastic tape attached to the carapace were released from beaches (2009/10: n=17, 2011/12: n=32) located on either side of the causeway. Vessel-based observers recorded position and behaviour at 60 second intervals.

**Hatchling movement**

Hatchling travel speed ($m.s^{-1}$) is a combination of hatchling swimming effort and sea surface currents. Hatchling travel speed increased where time-at-large and depth exceeded 2 hours or 4.8 m respectively; mean travel speed was significantly faster >2 hours-at-large ($0.40\pm0.23$ $m.s^{-1}$) compared to <120 mins-at-large ($0.31\pm0.14$ $m.s^{-1}$).

**Hatchling activity**

The level of activity is defined as the proportion of time spent engaged in various 'behaviours'. At >2 hours-at-large the most frequent behaviour observed was 'swimming at the surface' (61% of all observations). This dropped to 44% during 2-4 hours-at-large and dropped to 29% in the period >4 hours-at-large. The reverse trend involved 'resting in weed' observations where this behaviour accounted for only 3% of all observations during the first two hours, 37% during two to four hours-at-large and 56% of all observations >4 hours-at-large. Predation rate was 18% in 2009/10 in 43% in 2011/12 and in both surveys reached 0% >2 km from shore. Before the causeway was in place hatchlings released on the southerly beach travelled north-east over the future footprint of the causeway. Following construction, the majority (89%) of hatchlings typically swam parallel to the structure, successfully circumnavigated its perimeter and resumed a north-easterly track. Future research on dispersal and survival will aim to understand the influence of artificial lighting associated with the project under different lunar phases.

The Gorgon Project is operated by an Australian subsidiary of Chevron and is a joint venture of the Australian subsidiaries of Chevron (47.3 %), ExxonMobil (25%), Shell (25%), Osaka Gas (1.25%), Tokyo Gas (1%) and Chubu Electric Power (0.417%).

# Adaptive Capacity of Marine Turtles to a Warming Climate: a Full Transcriptomic Analysis

***Blair P. Bentley[1], Nicola J. Mitchell[1], Scott Whiting[2] and Oliver Berry[3]***

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Marine turtles are highly susceptible to the effects of global warming, especially during their embryonic phase, due to their temperature dependent sex determination, narrow thermal tolerance limits and long generation times (30-50 years). Anthropogenic climate change is predicted to significantly increase global ambient temperatures of up to 3.4°C in Australia by the year 2070 under a high emissions scenario. Understanding how embryonic marine turtles may respond to high temperatures during incubation is imperative in facilitating conservation efforts. This study compared loggerhead (*Caretta caretta*) turtles from Dirk Hartog Island in Shark Bay, Western Australia, exposed to a period of thermal stress (36°C for three hours) late in development (>80%) with a control treatment with a consistent temperature close to the pivotal temperature (29°C). Here, we use the Trinity platform for *de novo* transcriptome assembly with Trinotate utilised for downstream full transcriptomic analyses. Our preliminary results suggest thermal stress effects gene expression. Based on expression, a hierarchical cluster analysis produced two distinct groups. One contained all individuals exposed to the heat shock treatment and the other contained the control treatment individuals. By comparing the expression of these transcripts between populations, management strategies will be able to determine those populations that are at the highest risk of vulnerability to global warming. This study provides a foundation on which to build future studies to compare populations from thermally different nesting beaches and other species of marine turtle to determine if the observed expression changes are universal in marine turtles.

# Sea Turtle Monitoring Results Associated with Pluto LNG

***Tegan Box, Robert Hearn and Jarrad Taylor***

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Presenter - contact: tegan.box@woodside.com.au

Woodside is Australia's largest independent oil and gas company with a proud history of safe and reliable operations spanning decades. Woodside produces hydrocarbons from an extensive portfolio of facilities which we operate on behalf of some of the world's major oil and gas companies.

The Pluto gas field was discovered by Woodside in April 2005 approximately 190km west north west of Dampier, Western Australia. Gas from the Pluto field is exported, through an offshore riser platform and subsea trunkline to the Pluto Liquefied Natural Gas (LNG) Plant located on the Burrup Peninsula.

Woodside implemented a Sea Turtle Management Plan (STMP) as a State and Commonwealth environmental approvals requirement for Pluto LNG. The objective of this STMP is to provide a management framework to enable Woodside and its contractors to detect and mitigate, as necessary, any potential impact to marine turtles from Pluto LNG. As part of the STMP Woodside has also implemented a turtle nesting monitoring program at Holden and No Name Beach which are located adjacent to the Pluto LNG Plant.

Baseline monitoring at Holden and No Name Beach started in 2005, and was continued during construction of the Pluto LNG Plant. Monitoring was carried out daily between October and April during peak construction, and weekly as the project transitioned into the operational phase.

Surveys included turtle track counts, nest and body pit monitoring and nest fan measurements of all hatched turtle nests. Nest fan measurements were recorded to identify the behaviour of hatchlings in response to light during the sea-finding phase and to confirm the actual nesting activity on the beaches.

Results have provided insights into the continued nesting of turtles in proximity to the Pluto LNG Plant over the last seven nesting seasons.

Since construction commenced 19 successful nests as indicated by records of hatchlings emergence have been recorded at Holden and No Name Beach. Flatback and green turtle species have been recorded with the peak period of nesting activity in the months of November and December.

Monitoring results have revealed a high variability in the frequency of turtles nesting at the two beaches surveyed. At Holden Beach, records of turtle tracks (nesting activity) ranged from zero in the nesting seasons of 2008/2009 and 2011/2012 as compared to ten in 2009/10 and 14 in 2012/2013. Similar patterns in seasonal nesting activity variability were also observed at No Name Beach.

These data indicated that Holden and No Name Beach do not support major sea turtle rookeries and that potential impacts of Pluto LNG on turtle nesting activities have been negligible. A small number of individuals continue to use these beaches for nesting and the Pluto LNG monitoring dataset provides a useful time-series which contributes to the wider regional baseline status of marine turtle nesting activity in the Dampier Archipelago region.

# Mapoon Turtle Monitoring Project: Managing Turtles on Mapoon Sea Country, Western Cape, QLD

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The Mapoon Land and Sea committee in conjunction with the Mapoon Indigenous Ranger group representing the Traditional and historical owners of Mapoon have developed a land and sea management program to look after and manage sustainable populations of culturally significant saltwater animals found in Mapoon Sea Country area. Key aspects of the program include conservation and sustainable management of their turtle populations with a focus to answer some long standing questions Mapoon community have about the extent of turtle and dugong habitat and populations to more effectively manage their sea country.

Mapoon flatback and olive ridley turtle management program has been running since 2006, with an annual census program, community involvement, and operating as a centre for training other Indigenous Rangers across Cape York. Current results from this program indicate that greater than 30% of olive ridley clutches are being lost (predominately through predation) which requires conservation and management actions and for flatback turtles clutch loss is less than 30% and is currently considered sustainable.

This data has created an impetus to set up a marine hunters group who have drafted community guidelines for traditional harvest of turtle and dugong, development of ranger exchanges, ecology and sea grass monitoring training, aerial surveys, sea grass surves, a permit system for take of turtle and dugong in Mapoon Sea country and in development are activities for the mitigation of egg loss. The effectiveness of these measures requires long term monitoring, the integration of science and traditional knowledge and active participation of the community in sea country management decisions.

# Caught in Ghost Nets: Impact on Sea Turtle Populations in the Arafura and Timor Seas

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## Introduction

The incidence of debris in the marine environment is cause for concern globally. A review of literature on marine debris and its impact on biodiversity found that 663 species are affected through entanglement of ingestion (Secretariat of the Convention on Biological Diversity 2012), with a 40% increase of reported incidences in the past 15 years. High accumulation rates of marine debris on Northern Australian beaches have given rise to concern about the effect on the marine ecosystem (Keissling 2003). Lost and abandoned fishing gear dominate the debris and several years of beach clean-up data in remote areas have shown that a substantial diversity of nets drift into the Arafura and Timor Seas (ATS) of northern Australia (Heathcote et al. 2011). These shallow waters provide important foraging habitat for or are traversed by several species of marine turtles. Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris is listed as a key threatening process under the EPBC Act 1999, underlying the threat abatement plan for the impacts of marine debris on vertebrate marine life (Goldberg et al. 2012).

Understanding the level at which ghost nets pose a threat to sea turtle populations is difficult due to intrinsic uncertainties regarding the number of nets circulating in the environment at any point in time, the cumulative number of turtle entanglements, the mortality resulting from these entanglements and the impact of this mortality on populations. In an effort to inform effective management of the ghost net problem, we use several research approaches to identify high-risk areas for entanglement. Here we present a brief overview of preliminary results.

## Methods

All existing data sets on ghost nets in Australia, with the exception of the GhostNets Australia data, were compiled into one database and standardised. Oceanographic circulation modelling assesses if there are particular ghost net retention areas within the ATS, while satellite telemetry identifies important foraging

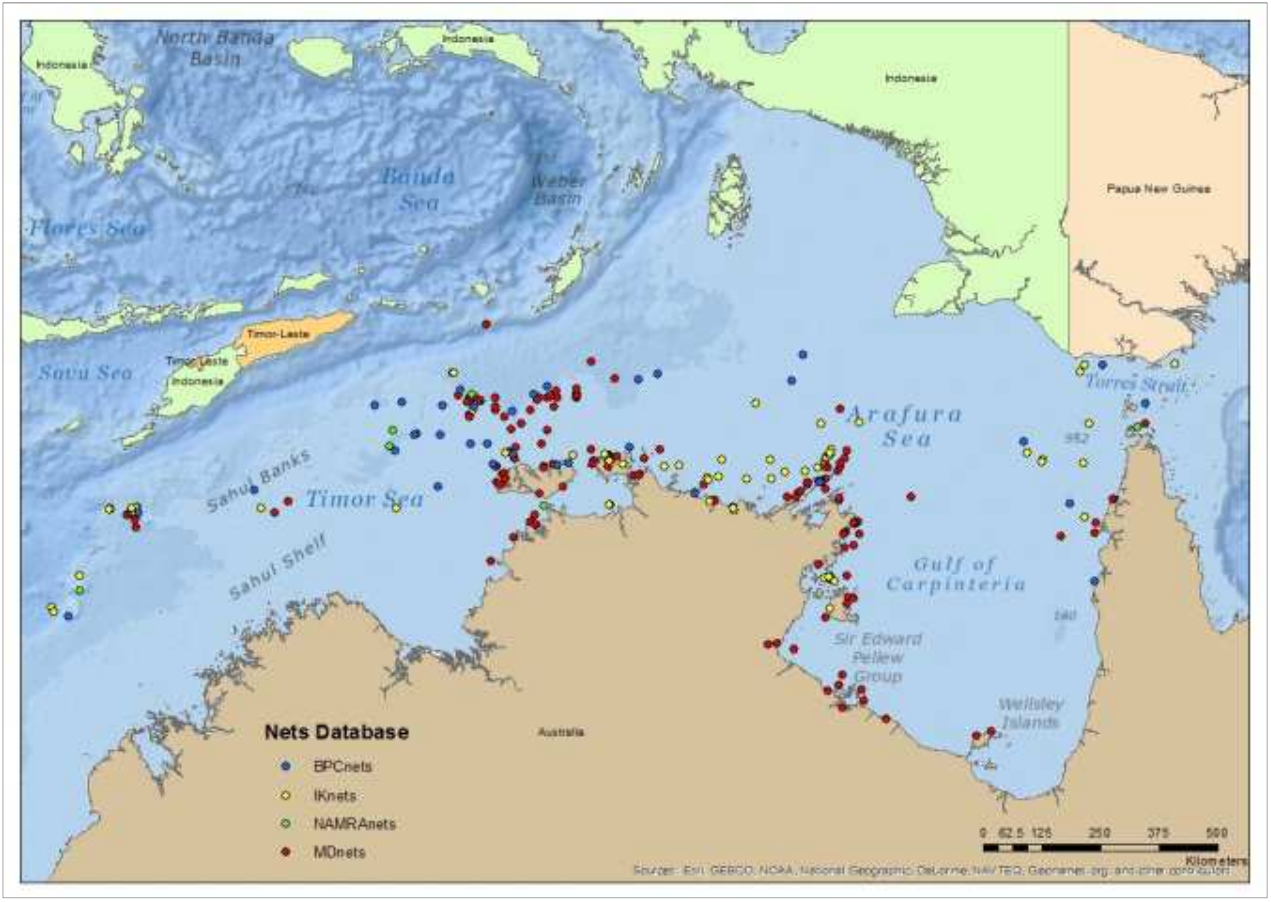


**Figure 1**. Observed ghost nets in the ATS (compiled from various datasets).

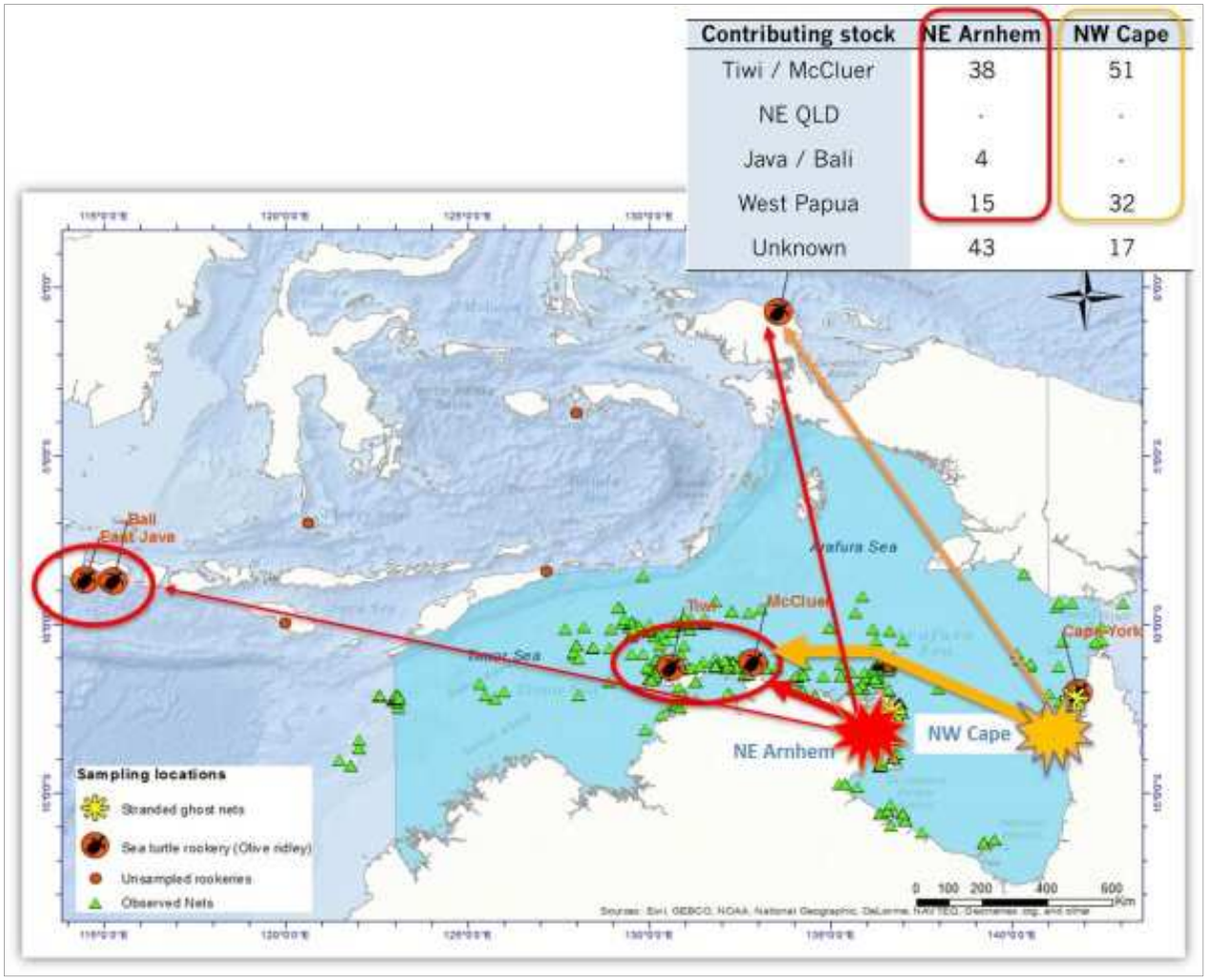


**Figure 2**. Mixed Stock Analysis of olive ridley entanglements at NE Arnhem Land and the NW Cape, in the Gulf of Carpentaria (adapted from Jensen et al. 2013 Jensen et al. 2013).

areas, and population genetics elucidates possible migratory connectivity between existing circulation models to predict drift trajectories of observed ghost nets in the ATS.

## Results and Discussion

Among 2700+ records (Figure 1), more than 50% of species entanglements in the ATS over the past 10-15 years were sea turtles but also included fish (30%), sharks (9%) and some whales, crocodiles and dugongs. The majority of entangled turtles were hawksbills (34%) and olive ridleys (27%), with a smaller proportion of green (14%) and flatback turtles (4%). Population genetic data analysis shows that among the larger proportion of olive ridleys found in nets that washed up on the shores of the Gulf of Carpentaria are animals that nest on Tiwi and McCluer islands in the Northern Territory, but that animals that nest in West Papua, Indonesia are also affected by ghost nets in the ATS (Figure 2).

In the case of at least the olive ridleys, two important conclusions can be drawn from these results: 1) the ghost nets affect multiple regional turtle populations and 2) turtles most likely become entangled at foraging areas, which are generally used by several genetic stocks. Indeed, satellite tracks of post nesting olive ridley turtles from both West Papua and NE Arnhem Land show that these widely separated populations share a common foraging area in the Arafura Sea (results not shown here). Habitat predictive modelling based on the satellite tracking data, is expected to provide a better understanding of the location of such foraging areas and if these areas coincide with ghost net retention areas.

Future analysis of this information will support conclusions regarding potential hotspot areas for ghost net and turtle interactions.

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## Acknowledgments


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# Ghost Nets and Marine Turtles of North-east Arnhem Land: Dhimurru Aboriginal Corporation's Indigenous Protected Area (IPA) Turtle Rescue Project

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Dhimurru Aboriginal Corporation (Dhimurru) manages approximately 550,000ha of land and sea on behalf of the Yolngu Traditional Owners and Custodians of Northeast Arnhem Land. Over the past 20 years, the Indigenous Rangers of Dhimurru have been active in the rescue of marine turtles found entangled along the 220km of remote coastline of the Indigenous Protected Area.

During the early dry season, south easterly winds wash tonnes of marine debris and ghost nets ashore on the Dhimurru IPA coast. Of particular concern are the increasing numbers of marine sea turtles discovered in ghost nets. For the most part the turtles are severely physically compromised by their entanglement or have perished due to these injuries, starvation or exposure.

In 2013, Dhimurru sourced funding from the Commonwealth Government to concentrate on repetitive aerial surveys early in the 2014 dry season. These surveys were designed to firstly identify and rescue entangled animals in order to quantify the effectiveness of earlier and more frequent surveys on the survival rates of turtles and secondly assess the number and frequency of new nets washing onto the coastline.

The results indicate that early and more frequent aerial surveys greatly increase the chances of finding marine turtles before they perish. The number of turtles found in nets overall was greater than in previous years and the number found alive and in a relatively robust state were above previous years. It is believed that releasing the animals in a more robust state potentially increases their survival rate.

# Raine Island Turtle Recovery Project: Conserving the World's Largest Green Turtle Nesting Site in Northern GBR, Australia

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Raine Island is the largest green turtle nesting site in the world, located on the northern tip of the Great Barrier Reef. The Raine Island Recovery Project aims to create a refugia for green turtles to ensure the security of the largest population remaining in the world. An estimated 90% of northern Great Barrier Reef green turtles nest at Raine Island and Moulter Cay. The lack of hatchling output over at least the last three decades will result in a drastic reduction of breeding adults at Raine Island in the future. A catastrophic decline within the northern Great Barrier Reef green turtle population is predicted within the next 10 years unless immediate actions to mitigate these problems are undertaken. The current estimated northern Great Barrier Reef green turtle population of around 200,000 mature female individuals is estimated to decline to around 50,000 individuals within 10 years under current conditions.

Detailed research has identified low reproductive success of green turtles at Raine Island and high mortality of nesting females. The 2013-14 research program was the most comprehensive to date during one of the largest nesting seasons (27,000 per night) on record. Results from this season demonstrate: nesting success is low (around 20%), overcrowding, nesting disturbance and clutch destruction may be a key factor limiting nesting success and hatchling production. Additionally, hatchling production is low ( < 10% from 370,000 eggs / night in December only 2,700 hatchlings / night in February and March) and adult mortality is high (10-15 /day). The main causes for these adult mortalities are cliff falls, becoming trapped in caves and beach rock crevices and exhaustion from disorientation in the swales. Microbial causes were investigated but showed no immediately obvious microbiological cause for egg death. Actions undertaken have included minimisation of adult nesting mortality by installing fencing to high risk cliff , methods to improve nesting and hatching success through sand movement have been investigated and trialled on a small scale in a 50m sector of the nesting area during 2013-14.

A major Raine Island intervention project is planned be run over five years to undertake adaptive management actions to reduce adult green turtle mortality and increase reproductive output. The current recommended actions moving forward include: reduction of turtle mortality by fencing and rescue, and increasing the viable nesting area by replenishment and re-profiling of sand well above peak water table height. Quantify sea level and weather pattern changes, sand replenishment which is predicted to provide a 300% greater area utilised by nesting turtles, reducing nesting disturbance and increasing nesting success. In-situ experiments at Raine Island using different incubation media / sand types to assess egg mortality in optimal conditions (are all laid eggs viable?). Additionally direct participation and training of indigenous rangers with EHP/QPWS staff at Raine Island and a program to impart key messages about the limited turtle resource and more humane and sustainable hunting of turtles will form part of the project.

# Shedding Light on the Sea Turtles of the Cape Byron and Lord Howe Island Marine Parks in NSW: Questions for Habitat Modelling, Climate Change and Conservation

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Populations of sea turtles in New South Wales (NSW) are little understood. Our knowledge of species, abundance and distribution combined with existing habitat models to describe greens, hawksbills and loggerhead turtle dynamics in NSW waters has been identified as a high research priority for conservation management. This project explores sea turtles in predicted suitable habitat across two temperate marine estates in NSW, the Cape Byron (Nguthungulli) and Lord Howe Island Marine Parks.

Quantifying predicted suitable habitat within Marine Park estates alongside analysis of visual surveys, historical records and tag recaptures is providing valuable insight into sea turtle abundance, distribution and behaviour in NSW. Sea turtles are seen daily in the Cape Byron Marine Park, some tagged, and have provided excellent marketing material for local tourist operators for some decades. Sea turtle appears in the local indigenous culture and is known as "Bing-ing". The history of sea turtles in the Lord Howe Island Marine Park is unique having been hunted by passing ships to being protected under listing as a World Heritage site. Sea turtle based tourism has been a recent development on the island and for a number of social reasons sea turtle never made it to the menu locally. There were no indigenous inhabitants on Lord Howe Island before its discovery by British sailors in 1788.

The results of this project will provide baseline sea turtle abundance and distribution data for two of the most significant marine sites in NSW that will inform conservation managers for improved strategic planning, monitoring and emergency response. Continued monitoring will also give rise to the capacity to detect and mitigate changes in abundance or distribution of sea turtles and their habitats as a result of climate variation or other pressures present or proposed in NSW waters.

# Turtles and the Oiled Wildlife Response in Western Australia: A Collaboration between Industry and Government

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Increasing shipping activity in addition to an increase in exploration and development of oil and gas resources in the waters off Western Australia has resulted in an unprecedented risk of a significant oil spill in WA. The resulting threat to wildlife from such an incident has the potential of being catastrophic depending on the area to be affected and the response to the spill. In response to this increasing risk the Department of Parks and Wildlife have begun working with the Australian Marine Oil Spill Centre, representing industry groups, to develop a collaborative approach to oiled wildlife response irrespective of the source of a spill. Through the development of a Statewide strategic plan and seven regional plans this collaborative approach is ensuring a standardised response to these low frequency yet high consequence incidents which have the potential to require enormous resourcing in a response.

The Statewide and regional response plans along with other lower level documents (e.g. standard operating procedures) provide guidance for preparation and planning in addition to activation of a response to an oiled wildlife incident. The State plan provides information on requirements for a response irrespective of the location within WA including personnel and equipment requirements, communication protocols and standard operating procedures. The regional plans provide the regional context to the state plan including the additional practical detail needed to activate a response at a known location. These plans provide guidance in the activation of a response without being overly prescriptive while empowering the responders to direct their efforts as deemed appropriate.

Our preparation for an oil spill event is crucial to ensure the greatest environmental success in any response. This industry/government collaborative approach will guide the oiled wildlife response whatever the source of the spill and ensure the maintenance of a standard across these events which will enable the greatest likelihood of success.

# A Decision Framework for Prioritising Multiple Management Actions for Marine Turtles

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Conservation funds are grossly inadequate to address the plight of marine turtles. Government and conservation organisations faced with the task of conserving marine turtles desperately need simple strategies for allocating limited resources. The whole array of management actions necessary to stop decline and support recovery of marine turtles is usually stated and described in their recovery plans, which aim to maximise their long term survival. Although recovery plans often provide a planned and logistical framework for policy makers to coordinate their work, the majority do not provide any support to help prioritise resources across identified management actions, and when they do there is no transparency of how priorities where decided. However, priority-setting frameworks are vital where conservation targets and management actions, within a species or population, are diverse.

We developed a novel framework that explicitly prioritizes actions to minimise the impacts of several threats across marine turtles' range. The framework uses a budget constraint and maximises conservation outcomes from a set of management actions, accounting for the likelihood of the action being successfully applied and accepted by local and Indigenous communities. This approach is novel in that it integrates local knowledge and expert opinion with optimization software, thereby minimising assumptions about likelihood of success of actions and their effectiveness. To test the framework, we used the eastern Gulf of Carpentaria and Torres Strait flatback turtle, *Natator depressus,* populations as a case study. This approach allowed the framework to be applied in a data-poor context, a situation common in conservation planning. The framework identified the best set of actions to maximise the conservation of flatback eggs for scenarios with different budgets and management parameters and allowed comparisons between optimised and pre-selected scenarios. Optimised scenarios considered all implementable actions to explore how to best allocate resources with a specified budget and focus. Pre-selected scenarios were used to evaluate current allocations of funds and/or potential budget allocations suggested by different stakeholders. Scenarios that used a combination of aerial and ground strategies to reduce predation of eggs performed better than scenarios that focused only on reducing harvest of eggs. The performances of optimised and pre-selected scenarios were generally similar among scenarios that targeted similar threats. However, the cost-effectiveness of optimised scenarios was usually higher than pre-selected scenarios, demonstrating the value of conducting a systematic optimisation approach. Our method provides a foundation for more effective conservation investments and guidance to prioritise actions within recovery plans while considering the socio-political and cultural context of decisions. The framework can be adapted easily to a wide range of species, geographical scales and life-stages.

# Community Based Turtle and Dugong Management Plans in the Torres Strait

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Since 2008 the TSRA has worked with communities and local government stakeholders to develop and implement 14 community based Dugong and Turtle Management Plans in the Torres Strait. These plans detail each community's objectives, concerns, priorities and traditional management regulations for the continued sustainable and cultural harvest of turtle and dugong. They are a blend of cultural and western management systems: supporting community control and empowerment, respecting cultural values and traditional knowledge, conserving natural and cultural values, and developing collaborative partnerships with relevant expertise to assist in implementation.

All plans have Traditional Owner endorsement as well as endorsement from Queensland and Federal governments. However, they are voluntary and not legislated which requires regular community collaboration to ensure a high level of adherence. There are currently 36 Indigenous rangers employed across the 14 communities to drive the management plans locally with the support of the TSRA Land and Sea Management Unit's Sea Team by undertaking specified tasks such as community and school education, recording community catch, responding to breaches and building capacity through participation in research and annual monitoring of populations.

The development and implementation of the plans is a progressive journey which needs to adapt to arising challenges. The Torres Strait faces numerous challenges in regard to the continued sustainable management of marine turtles in a regional, inter-state and international context. The TSRA will continue to collaborate with Traditional Owners, communities, partners and stakeholders to address these challenges while abiding by the fundamental guiding principles of community based management.

# Nocturnal Avian Predation of Flatback Sea Turtle Hatchlings, *Natator Depressus*, On Bare Sand Island, NT

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Predator avoidance is one of the considered strategies for the development of nocturnal and synchronous emergence in sea turtle hatchlings. This study aimed to capture footage of nocturnal predation on sea turtle hatchlings by avifauna on the Bare Sand Island sea turtle rookery, using budget infra-red game cameras. We sought to identify the avian predators of flatback hatchlings on the island and the densities of nocturnal avian activity. Additionally we assessed the usefulness of game cameras to observe predation on a sea turtle rookery.

**Study site**

Bare Sand Island (12°32' S, 130°25' E) lies 50km west of Darwin in northern Fog Bay as the seventh of a string of eight islands extending 12km from the mainland (Whiting and Guinea 2003) and is currently a landscape of sand dunes with low shrubs. This study was conducted during the wintering nesting peak of flatback sea turtles (*Natator depressus*).

**Methods**

Six infra-red game cameras (ScoutGuard SG560D 5MP x2, LTL5210A 12MP x2, SG660 12MP x2) were set up to film and photograph predation events on flatback hatchlings post emergence. The cameras were strapped to 1m lengths of PVC pipe (90mm width) and the end portion of the pipe partially buried in sand for stability of the camera at a height of approximately 80cm. The cameras were trialled in varying positions for their effectiveness to film and photograph hatchling and predation activity, at sites chosen for likelihood of hatchling and predation activity, according to the presence of shallow depressions in the sand (sign of an emerging nest), evidence of nesting, or popular areas for nesting. Cameras were also trialled for the effectiveness to film foraging predators at baited sites, where deceased turtle hatchlings and egg shells retrieved from nest excavations were placed in front of cameras to encourage predation activity.

***Results***

Of 21 evenings of filming, the cameras captured over 400 videos of avifauna activity on the sea turtle nesting beach, including predation of 28 live flatback hatchlings post emergence from the nest. The majority of these predation events occurred between 00:00 and 02:00 by nankeen night herons (*Nycticorax caledonicus*). This species was recognised in high densities on the beach (see Figure 1a) with some footage showing anywhere up to 20 nankeen night herons in a still image, and flocks of up to 30 were filmed flying through the field of view of the camera. Unlike Burger and Gochfeld's (2014) observation of yellow-crowned night herons (*Nyctanassa violacea*) preying on olive ridley (*Lepidochelys olivacea*) hatchlings at dawn and dusk, the nankeen night herons on Bare Sand Island were only filmed during the night (dark hours) and it is likely this species is only present on the beach during the night. The herons were rarely seen or heard on the beach during the patrols of volunteers for sea turtles, despite their high foraging densities.

Thirty one hatchlings (both live and bait) were filmed consumed by the night herons. There is much shaking and repositioning of the hatchlings in the beak when collected by these herons, a behaviour which was easily recognised in the footage even in low light. From these events it is clear that there is a lengthy handling time, of up to a minute (as with the bird shown in Figure 1b), for these herons to swallow the newly hatched turtles. The footage highlights the advantage of flatback hatchling size and synchronous emergence for the hatchlings' predator avoidance, due to predator swamping occurring, with each heron limited to consuming hatchlings slowly and one at a time.

In the presence of an emerging nest the night herons would dart about snatching up hatchlings or chase and harass other herons with hatchlings, but, the majority of the footage captured the birds standing crouched or alert and moving very little. The birds were not filmed displaying behaviours to suggest they were actively searching for hatchlings. Also, the movement of the birds in and out of view was often unidirectional, where many would

move or look towards one direction and others would follow until all the birds had disappeared in a particular direction. These behaviours suggest that the herons are communicating with each other, most likely indirectly, responding to an acoustic or other cue of herons discovering newly hatched nests. It also assists to explain how birds may heavily predate hatchlings of one emerging nest, while hatchling tracks of another nest are without noticeable signs of avian predation. It appears hatchlings of an emerging nest that is discovered by a flock of herons must outnumber the herons for a chance to survive the crawl to the water.

A bolus of a nankeen night heron (shown in Figure 1c) containing undigested remains of flatback hatchlings was discovered on a dune. After sorting the contents we recognised rear flippers of flatback hatchlings, at least two full sets of costal and central scales, and three hatchling beaks, and so were able to conclude that this bird had consumed at least two flatback hatchlings, and likely more from earlier meals such as the previous evening.

Unlike the night herons, footage of black-necked stork was captured during the night and daylight of the early morning; a total of 66 occasions from 12 separate evenings. The footage of this species shows a single stork present but cannot be identified as the same bird. Whereas live observations of black-necked storks were comparable to those of Whiting & Guinea (1999), the birds were seen on three separate mornings between 0730 and 0800 on the western and eastern facing beaches, twice in pairs. On 26 occasions the black-necked stork was filmed with nankeen night herons (e.g. Figure 1d), and moving in the same direction as the group. Storks appeared to respond to the same cues as the herons during the night and showed interest in the commotion often made by the herons. On another occasion where the black-necked stork was seen to quicken its pace and move directly towards a silver gull (*Chroicocephalus novaehollandiae*) investigating bait on the sand, we see evidence again of indirect communication between species to locate hatchlings. The black-necked stork were more flighty than the nankeen night herons and were often filmed flying away, having seemingly been startled by the triggered camera. Obtained footage of hatchling predation by this species is limited to pecking egg shells and carrying bait hatchlings in early morning daylight. There was no evidence of the black-necked stork using its beak to extract eggs and hatchlings from nests as Burger and Gochfeld (2014) found of wood stork (*Mycteria americana*).

Other predators of hatchlings filmed include silver gull and white-bellied sea eagle (*Haliaeetus leucogaster*) in the early daylight hours. The beach stone curlew (*Esucus neglectus*) and oystercatchers (*Haematopus longirostris* and *H. fuliginosus*) were both likely nocturnal predators of flatback hatchlings at this rookery. However their foraging appears to be limited spatially to the water's edge, where staging the cameras proved to be ineffective and difficult.

Sea turtle hatchlings did not trigger the motion sensors of the cameras, but were visible crawling on the sand in footage triggered by bird movement. Of the ScoutGuard camera models, the SG560D captured consistently usable footage of relatively high quality and reliable triggering sensitivity. The SG660 often captured avian activity although the image was often very dark and it could be difficult to observe behaviours. The LTL5210A had poor light penetration (850nm) and the resulting field of view was very small on dark evenings, however produced clear colour footage in the early morning. Generally, video footage was more useful in capturing predation events and avian activity than still images.

**Conclusion**

The use of infra-red game cameras at sea turtle rookeries is a recommended method for identifying and cataloguing predators. This study is a beginning step towards understanding natural predation of sea turtle hatchlings on an undisturbed rookery and the role hatchlings play as a food source for native foraging birds. With up to 30 nankeen night herons foraging for flatback hatchlings on Bare Sand Island each night and consuming multiple hatchlings each, and with the additional presence of a foraging black-necked stork, avian nocturnal predation is likely to be having a substantial impact on hatchling survivorship, as few hatchlings appear to be successfully crawling to the water. Preliminary examination of the number of hatchling tracks that appeared to successfully crawl to the water showed that 100% of emerged hatchlings of 14 nests were predated by nocturnal avian predators within an opportunistic subsample of 35 nests. Future investigations will seek to quantify the impact of avian predation on the population dynamics of Bare Sand Island nesting flatback sea turtles, and identify the behavioural and physical features of hatchlings that make them locatable by the night herons.

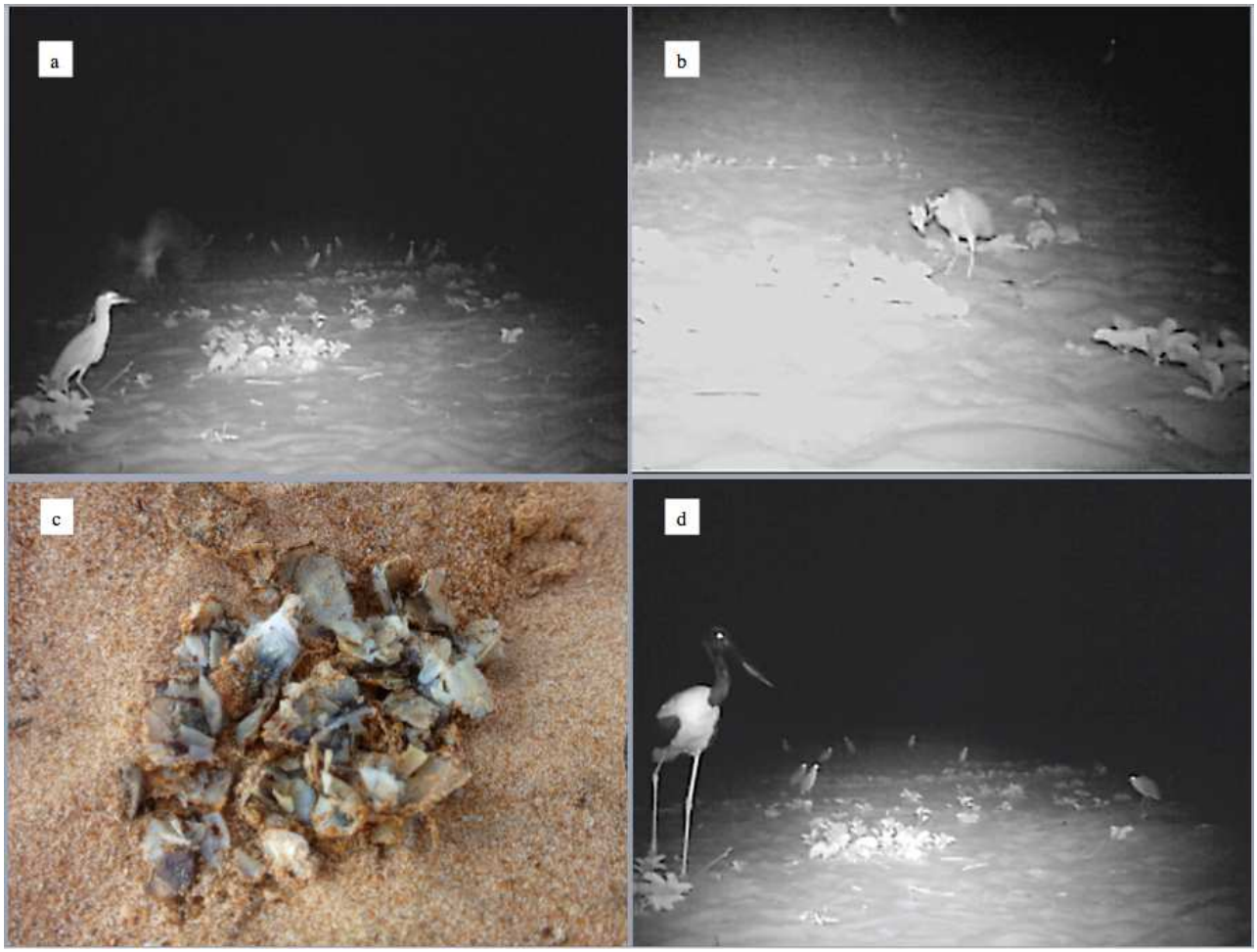


**Figure 1.** Infra-red still images captured of a) a large group of nankeen night herons (17 visible) standing on the beach, demonstrating the high density in which this species forages for hatchlings at night, b) a nankeen night heron as it shakes a flatback hatchling in its beak in an effort to swallow it, c) the bolus from a nankeen night heron with rear flipper and scales of hatchlings evident and d) a black-necked stork standing with a group of nankeen night herons (at least 10) demonstrating how these two species were often filmed foraging on the beach together.

## Acknowledgements

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# A Review of Light Monitoring Techniques and Instruments: the Good, the Bad, and the Illuminated

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Light pollution has long been known to negatively impact marine turtle behaviour. It can confuse natural orientation cues in adult and hatchling turtles of all species, on nesting beaches and offshore. Simple biological indicators of behavioral orientation exist (bearings to indicate offset and spread), but an equivalent does not exist for light pollution.

Despite a variety of instrumental methods for monitoring light pollution, the published literature on its measurement is limited. Common instruments used to quantify light pollution include: radiometers and photometers, light meters such as a lux meter or sky quality meters, and various forms of camera.

Not all of these may be suited to marine turtle orientation studies. The ideal instrument will be capable of measuring light in regions of the visible spectrum suited to marine turtle studies. It would require sufficient spectral, and spatial, accuracy and resolution. It would also have to be suited to a field environment.

Determining which of these technologies is most suitable for marine turtle orientation studies requires: consideration of the scientific principles behind the operation of each instrument, field trials of each instrument, and academic consensus behind which of these instruments and methods are most appropriate. A majority of technologies are not adequate to capture the data required, or are unsuitable for monitoring in a beach environment.

# Crunch Time: Population Analysis of Kakadu National Park's Field Island Flatback Turtle Nesting Data (2002-2013)

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Field Island in Kakadu National Park (KNP), Northern Territory supports a nesting population of flatback turtles that has been monitored since 1990. At the request of Kakadu National Park management, the Field Island nesting data (to 2013) was analysed with methods consistent with other northern Australian flatback nesting populations for comparable population trend analysis.

Capture-mark-recapture (CMR) modelling was undertaken in program MARK with nesting flatbacks that had presented in a season on the Field Island nesting beach. Cormack-Jolly-Seber model assumptions of transience (seen once and never again) and capture heterogeneity (known as trap-dependence) were evaluated using program U-CARE (Choquet et al. 2009). The lack of fit was significant due to turtle nesting behaviour (i.e. trap-shy due to nesting in the previous year). To account for this, a time-since-marking model structure was applied which addressed the variability in transient behaviour (Chaloupka and Limpus 2002) and a trap-dependent recapture structure to account for capture heterogeneity (trap-shyness). A Median *c*-hat approach was implemented in program MARK (White et al. 2006) to estimate over-dispersion in CJS model (*c*-hat =1.18). Therefore, the model selection metric (AIC) was not adjusted.

The best-fit model based on QAICc (incorporating constant time since marking, curved carapace length, trap-dependence, and rain) was then used to estimate apparent survival and recapture probabilities. This modelling approach also enabled a derived estimate of parameters for the population such as annual abundance by applying a Horwitz-Thompson-type estimator (Chaloupka & Limpus 2001).

A summary of findings for the Field Island flatback study include:

- Recapture decreases with increase in rainfall
- Survey effort had limited influence on recapture
- Annual survival is high and increases with increasing body size
- The Field Island nesting flatback population is generally stable.

# Conservation and Sustainable Management of Resident Green Turtles in the Northern Great Barrier Reef, Queensland

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Embayments and coastal reefs of North Queensland have supported some of the highest density green turtle (*Chelonia mydas*) foraging populations in the Pacific Ocean. The hunting and sharing of traditional food, such as green turtles, is an important part of Indigenous Australian culture. However recently, people have been concerned that a declining population may mean an end to their customary practice. In order to make informed management decisions, Traditional Owners of the Gudjuda Aboriginal Reference Group near Bowen, in the northern Great Barrier Reef, have been working with government and non-government organisations to study the population structure, trends and health of resident foraging green turtles in Edgecumbe Bay. To date approximately 1,100 green turtles have been tagged and recapture rates are estimated at around 40%. Abundance, survival rate, and recruitment rate are estimated using capture-mark-recapture analysis.

This data is crucial for understanding the long term viability of the local marine turtle population, and will be used to develop sound conservation management strategies by the Traditional Owners and government agencies including the Great Barrier Reef Marine Park Authority and Queensland Department of Environment and Heritage Protection.

A more detailed understanding of the marine resources in the Bay will also provide benefits to all users of the Great Barrier Reef Marine Park about the conservation status of green turtle populations and local movement of individuals within this ecosystem.

Rangers from the Gudjuda Aboriginal Reference Group are now well placed to continue the population monitoring study, and with continued training and support by government agencies and non-government organisations will see the community take sole responsibility for data collection and decision making contributing to the management of their Sea Country into the future.

# Assessing Seasonal Hatching Success of Flatback (*Natator depressus*) Sea Turtles from Hatchling Track Count Data at Bare Sand Island, NT

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Many sea turtle programs monitor nesting beaches for only a couple of weeks each year usually at the peak in nesting activity. During the monitoring period the numbers of nests laid and hatched are recorded. In some cases the hatching and emergence success of hatched nests are investigated. The peak of hatching activity is expected to be some seven to ten weeks after the peak of nesting but logistical restrictions may prevent a prolonged assessment of seasonal hatching success. For a sea turtle population to be stable, 80% of eggs should hatch from 70% of the nests laid with 70% of the hatchlings being female (Limpus 1993). However it is difficult to remain in the field to ensure such conditions are met.

A year-long survey of green turtles nesting on Bramble Cay (Limpus et al. 2001) provides compelling evidence the pattern of nesting follows that of a normal curve (Figure 1).

A normal curve has been fitted to the numbers of nests and adults in peaked intensive as well as to prolonged and protracted nesting seasons (Guinea unpubl. data, Whiting et al. 2013). In this study, it is assumed the pattern and timing of hatched nests also follow the logistic equation (Figure 1).

Cumulative numbers of freshly laid nests and hatched nests were analysed for the flatback turtle nesting population at Bare Sand Island (12.535112° S 130.422467° E) for the nesting seasons from 1996 to 2014. These data were fitted to the logistic equation for population growth (Zar 1974, Krebs 1985, Walsh and Diamond 1995, Rispoli et al. 2010) to produce asymptotes providing the estimates of the maximum number of laid nests and the maximum number of hatched nests for each year of the study. The constraints on accepting the output included:

- the number of nests laid is greater than the number of nests hatched,
- the numbers of nest laid exceeds the number of nests sampled,
- the peak of nesting (June/July) precedes the peak of hatching,
- the start of the nesting season precedes the start of hatching,
- the goodness of fit ( $\chi^2$) equals 1,
- the most conservative answer is accepted in ambiguous situations.

Bare Sand Island is an ideal study site for nesting flatback biology. The island receives fewer than 500 nesting females per season. The majority of nesting occurs on the western beach that is 700m in length (Figure 2). Nesting occurs within three hours of the night-time high tide. Consequently with eight to ten volunteers patrolling the island, there is a high probability of encountering nesting females and their nests as well as hatched nests.

The seasonal hatching success for flatback turtles on Bare Sand Island ranged from 48% to 84% (mean = 66% s.d. = 0.09) (Figure 4). The relationship between the numbers of hatched nests to the numbers of nest laid on Bare Sand Island was very strongly correlated at approximately 72% (Figure 5). Based on the desired seasonal hatching success, the flatback nesting population at Bare Sand Island appears to be coping well.

Calculating the seasonal hatching success is important when assessing the impact of egg depredation. A simple rule of thumb or protocol will enable an assessment in real time but still an end-of-season assessment is required. Seasonal hatching success provides an early warning of at least one sea turtle generation ahead of an impending collapse of the population. However, it is not until each stage of the life history is assessed that a degree of confidence can be placed on the stability of the population.

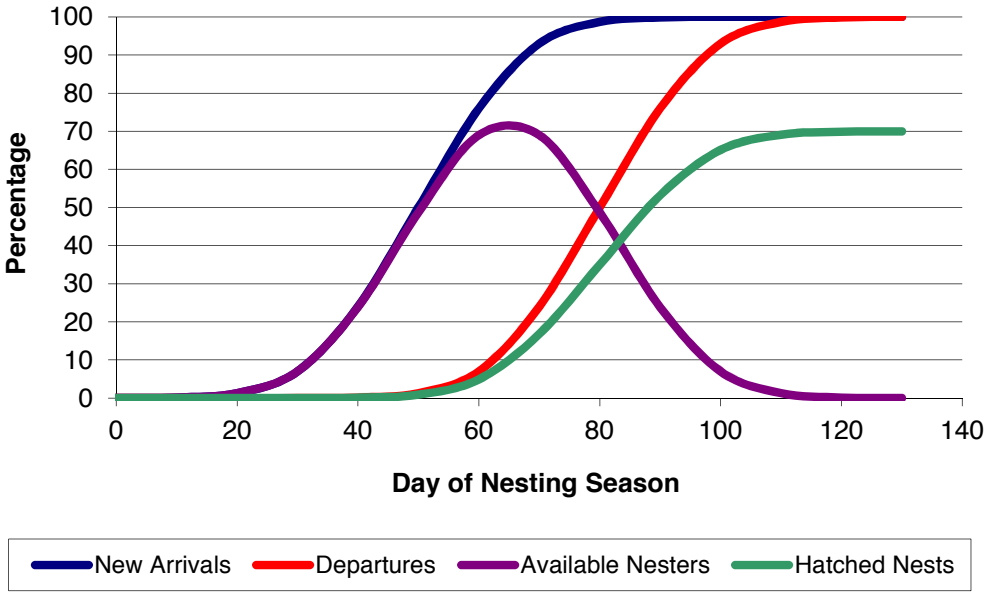


**Figure 1**. Pattern of the sea turtle nesting season showing the cumulative percent of new turtles arriving, the cumulative percent of turtles departing and the difference between the patterns resulting in the percentage of the nesting population present during the season (normal curve) and the presumed cumulative percent of hatched nests. Drawn from Limpus et al (2001).


**Figure 2**. Bare Sand Island showing the distribution of flatback turtle nests.

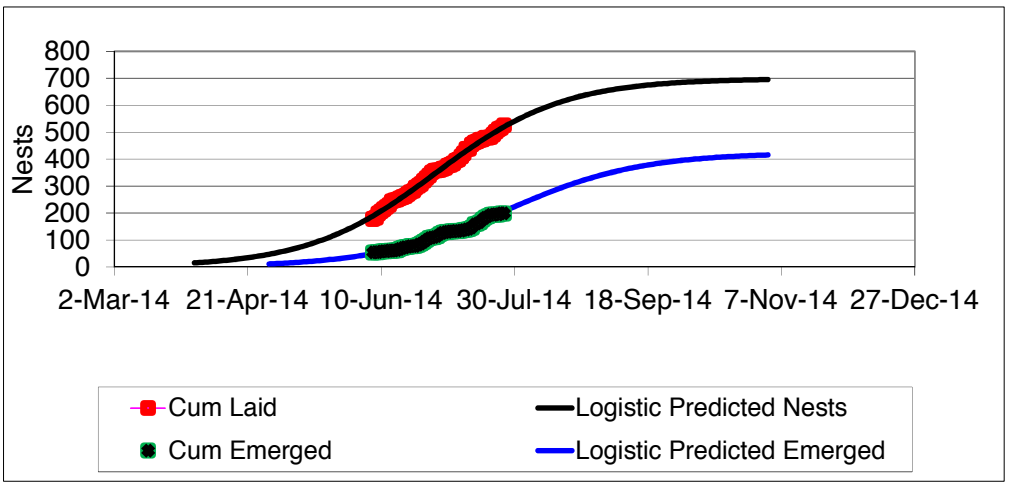


**Figure 3**. Cumulative number of laid nests and the cumulative number of hatched nests from June 9 to July 26 2014 on Bare Sand Island fitted to the respective logistic equations.

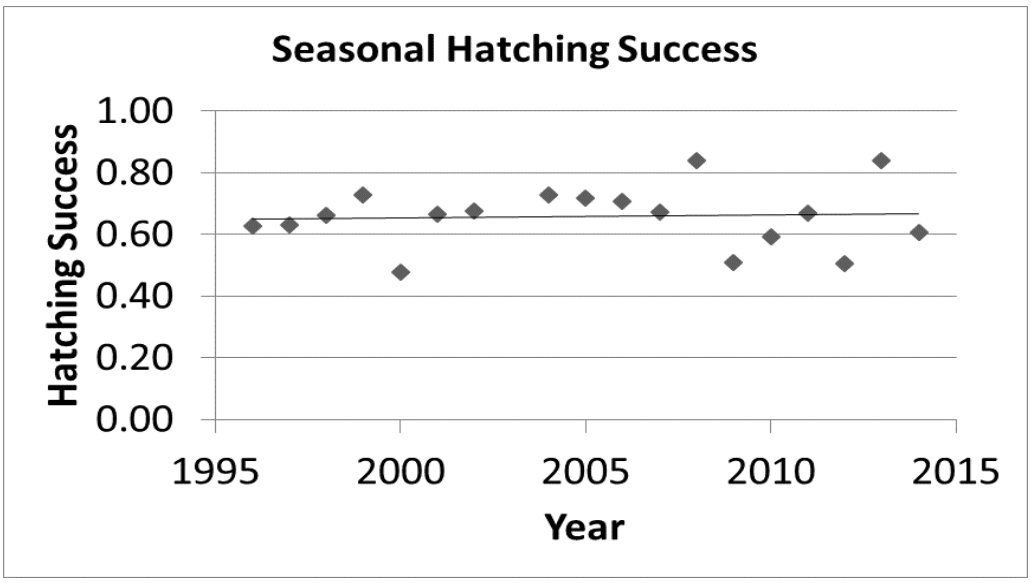


**Figure 4**. Seasonal hatching success of flatback turtle nests on Bare Sand Island from 1996 to 2014.

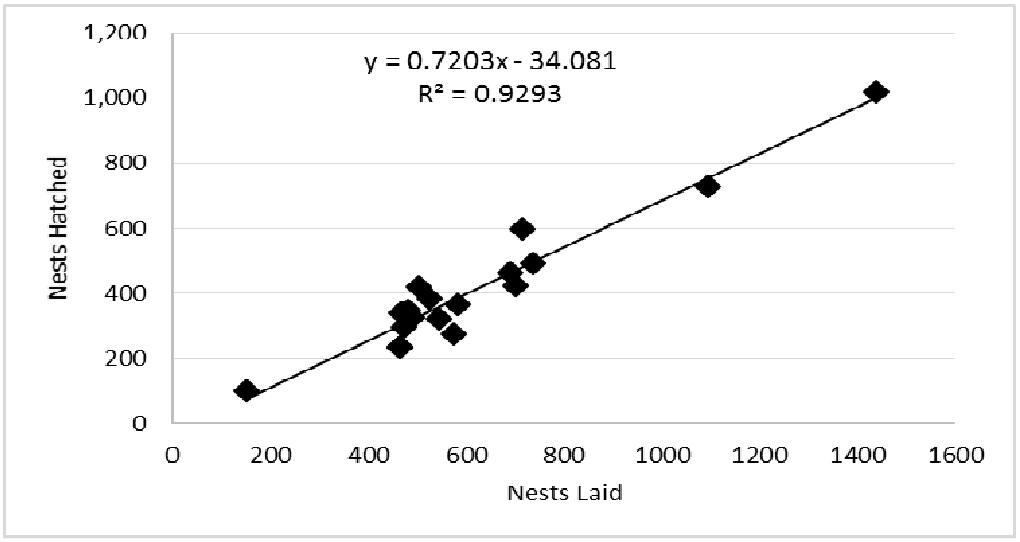


**Figure 5**. The relationship between the number of nests laid and the number of nests that hatch is highly correlated.

**Acknowledgements**

I thank Andrea and Scott Whiting, Dean Wright, Andrew Raith, Christine Giuliano, Nirmala Nath and the hundreds of AusTurtle Inc. volunteers for walking the beaches and collecting the data.

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# Sounds Emitted by Flatback (*Natator depressus*) and Olive Ridley (*Lepidochelys olivacea*) Sea Turtle Hatchlings

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Communication in marine turtles is a neglected field of study. The mechanisms to initiate synchronous behaviours such as migrating for breeding, mating behaviours and arrival at nesting beaches remain unexplained. Studies revealed terrestrial and freshwater turtles emit a number of different sounds (Frazier and Peters 1981, Giles et al. 2009, Ferrara. et al. 2014a, Ferrarat et al. 2014b). Investigations into sound emission from sea turtle hatchlings are only recent despite researchers being aware of hatchlings emitting sounds after hatching (Ferrara et al. 2014c) and within the nest (Ferrara et al. 2014b).

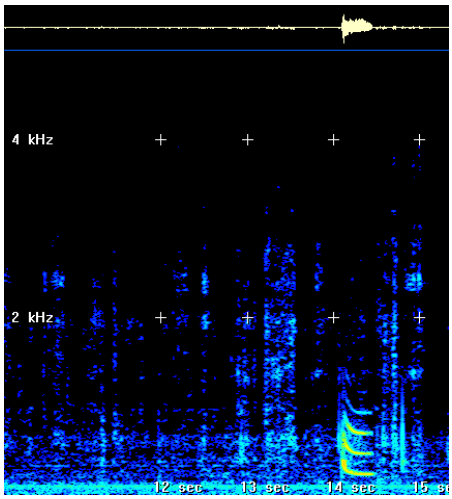
First evidence of hatchling flatback (*Natator depressus*) and olive ridley (*Lepidochelys olivacea*) sea turtles emitting sounds were recorded at Bare Sand Island in June and July 2014. Hatchlings were encountered during routine nest excavation approximately 12 hours after the nest emerged onto the beach. Hatchlings were kept at air temperature in containers with either moist sand or fresh sea water.

Sound emissions were voluntary and not induced. Recordings were made after individuals started emitting sounds under natural field conditions Recording equipment consisted of an IC voice recorder (Sony ICD-UX200F), a lapel microphone (unspecified), and at times a mobile phone and a Mac computer. The recordings were converted from mp3 to wav format using Audacity or AVS Audio Converter. Spectrograms were produced using Dolphinear Gram software which used Fast Fourier Transform (FFT) at 2400 FFT with peak frequency 4000 Hz.

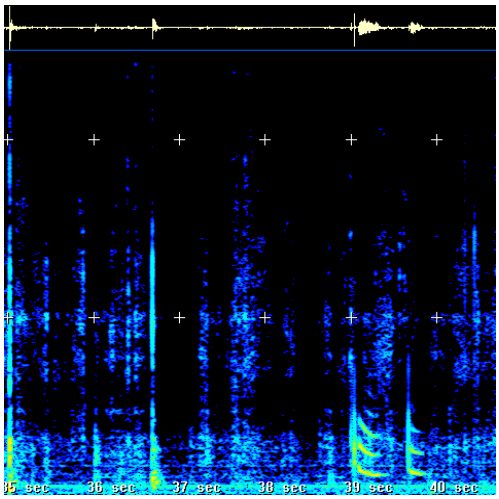
Spectrograms (Figure 1) revealed the complexity of the emitted sounds which differed from unstructured noise. Sounds recorded in air and in water were similar in spectral structure. The most common sound was similar to that of a “contact call” reported in other species of both marine and freshwater turtles. Amongst the repertoire of sounds were single and double calls with some having upward or downward swoops and others with inflections in the harmonics. Frequencies were typically below 4000 Hz with duration of less the 260 ms.

The sounds produced by flatback and olive ridley turtles are similar to those of other species of sea turtle hatchlings (Ferrara et al. 2014c, Ferrara et al. 2014b) and fall within the audible range of green and loggerhead hatchlings (Dow et al. 2009, Martin et al. 2009). Such sounds may assist in synchronising hatching and emergence from the nest. Sound emission and reception amongst sea turtles may assist in explaining the synchrony of encounters of groups of sea turtles on nesting beaches and feeding areas which suggests some cohesion or cryptic social organisation.

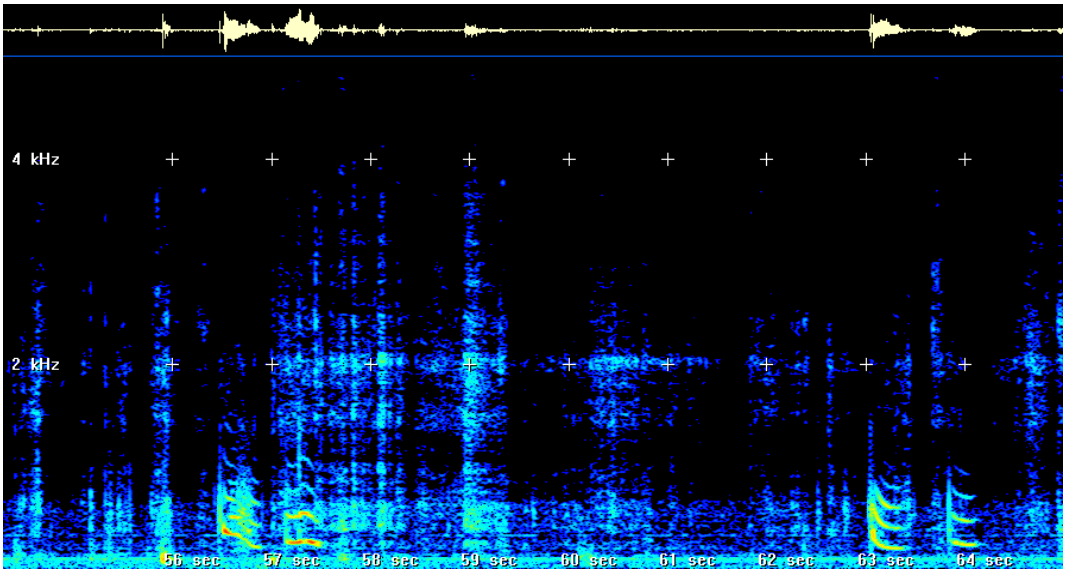
The frequencies fall within that of anthropogenic noise such as shipping and vehicle noise and pedestrian traffic on nesting beaches. Nocturnal predators such as birds and crabs may be alerted to hatchling emergence by the sounds emitted by individuals. These preliminary results suggest sounds emitted by hatchling flatback and olive ridley sea turtles are important in synchronising behaviour and survivorship.



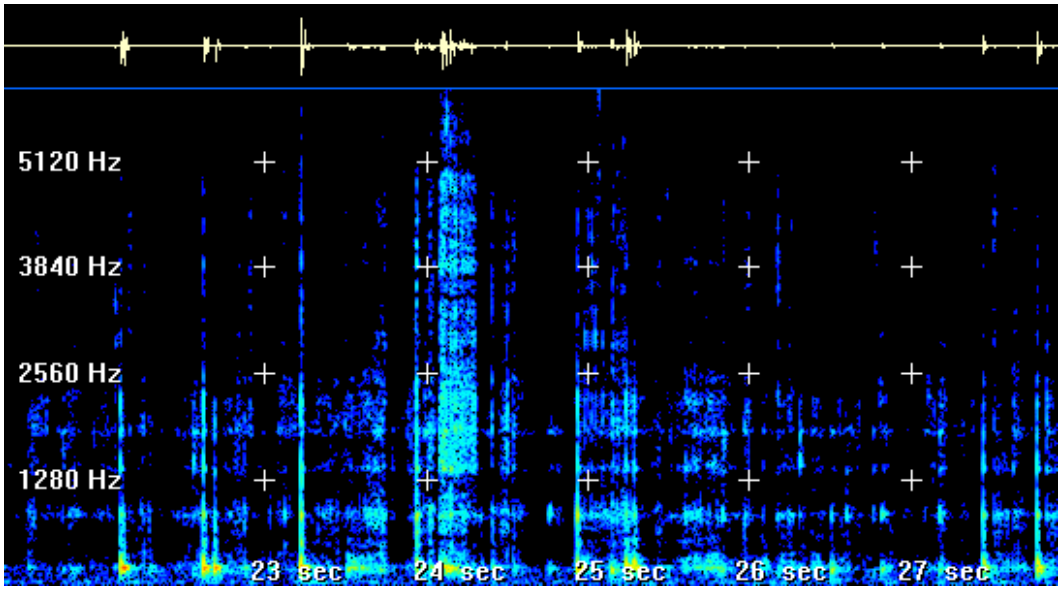

Single flatback sound




Double flatback sound




Double flatback sound emissions with inflections and downward swoops




Spectrogram of a double sound emission from an olive ridley hatchling

**Figure 1.** Spectrograms of flatback and olive ridley hatchling sound production.

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# Integrated Fox Control for Turtle Conservation at Ningaloo Coast World Heritage area

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The control of European red foxes *Vulpes vulpes* at turtle rookeries along the North West Cape is an essential management strategy to help improve the conservation status of endangered breeding sea turtles. In years gone by, foxes have had a significant impact on the nesting success of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles along the Ningaloo Coast.

An integrated feral animal control strategy based on adaptive management was introduced within the Ningaloo Coast World Heritage area (NCWHA) by Department of Parks and Wildlife in partnership with the Commonwealth Government's Caring for our Country program in 2012.

The program incorporated the use of soft jaw leg-hold trapping in conjunction with 1080 baiting. Different 1080 bait types where used and preference between them determined using remote cameras to show which baits were preferred by foxes at any one time in the year. A fox track-monitoring project was also implemented to determine the presence of these animals in and around turtle rookeries.

Capacity building within the local community saw the development of an Aboriginal trainee ranger. Strong emphasis was placed on the development of feral animal control skills which were practiced within the NCWHA.

In an effort to develop stewardship and improve protection, in-kind and financial support was provided to pastoralists adjacent to turtle rookeries.

Further development of fox control methods, technologies and baiting regimes are necessary to ensure the continued suppression of their impacts on threatened species.

Maintaining low numbers of foxes and reducing their impacts on nesting turtles is dependent on long-term financial commitment by private stakeholders and government alike. Using all of the available control methods in a dynamic way that caters for changes in the natural environment is the preferred approach.

# The Monitoring, Conservation, and Securing the Future of Flatback Turtles in Port Hedland, Western Australia

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The flatback turtle (*Natator depressus*) is the only species of marine turtle endemic to Australia. Flatback turtles are classified as vulnerable, with human activities one of the main threatening factors.

Port Hedland is 1,800km north of Perth, in the resource rich Pilbara region of Western Australia. Port Hedland is situated on the traditional land of the Kariyarra people.

Sea turtles have had a long association with the local people of Port Hedland. Local Aboriginal rock carvings depicting green and flatback turtles have been dated to approximately 8,000 years of age.

But much has changed in the Port Hedland area and in recent times this change has led to the Port Hedland harbour being the largest bulk tonnage port in Australia and second only to Brazil.

Today with a population of 18,000 people Port Hedland and its associated beach areas, are a far cry from what they once were. This change is set to continue with continued increased residential development and the Port Hedland Outer Harbour proposal still being touted to occur within the current decade.

In late 2003, the Care for Hedland Environmental Association started a volunteer turtle monitoring program, in conjunction with World Wide Fund For Nature (WWF), Department of Conservation & Land Management (CALM) and local school groups to monitor and record the level of flatback turtle nesting and hatchling activity at the two local beaches of Cemetery Beach and Pretty Pool Beach.

Cemetery Beach is unparalleled to any other sea turtle nesting beach in Australia, situated right in the heart of a residential township and supporting a critical mainland nesting area for flatback turtles. Pretty Pool Beach area is still in the sights of a proposal that will see an extension of the current residential development in the immediate vicinity. Each of these beaches is predisposed to a number of threatening factors that could detrimentally affect the turtles nesting in the area: high level of disturbance by people (direct contact, off-road vehicles, tourism and disturbance of nests and Indigenous take, harbour dredging), residential lighting and feral animal predation. The monitoring methods used are based on a track identification method and a mark-recapture program to determine the distribution and abundance of Port Hedland flatback turtles during nesting.

Key data summary from 2013/2014 monitoring season:

- 569 nests and 419 false crawls recorded on Cemetery Beach
- 60 nests and 47 false crawls on Pretty Pool
- 256 hatched nests on Cemetery Beach and 37 hatched nests on Pretty Pool
- 67 disturbed nests on Cemetery Beach from different disturbance events: goanna predation, tidal inundation, damage from cyclone Christine, nest exposure, customary take, take for scientific purposes and unidentified human disturbance
- 202 individual turtle were encountered during a 50 consecutive-day period of tagging
- 19% recruitment rate

This project has been going for 10 years and in that time it has already been able to deliver quantifiable data that has been able to be input into management decisions, particularly in regards to the impacts of fox predation, land based recreational activities, dredging and port construction activities and proposed residential developments. It has also promoted the development and distribution of education materials and a film documentary that has acted to greatly raise awareness about flatback turtles and the threats to these local populations.

# Daily Activity Patterns and Site Fidelity of Juvenile Green Turtles (*Chelonia mydas*) at a Shallow Near-shore Site in North Queensland

***Amy Huth, Mark Hamann and Julia Hazel***

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Coastal areas have the fastest expanding human populations in Australia. Green turtles (*Chelonia mydas*) that use shallow near-shore habitat areas are at particular risk from the degradation of coastal marine habitats due to anthropogenic processes. It is imperative to gain an understanding of how both ecological processes and the aforementioned stresses affect populations of green turtles so that management strategies can be employed to protect them, and their key habitats. The purpose of this study was to investigate the behaviour of juvenile green turtles at our selected long-term study site, Toolakea Beach near the tropical city of Townsville, one of the highest growth regions in Queensland. In particular I aimed to: 1) evaluate daily diving behaviour patterns by using time-depth recorders and 2) assess site fidelity. GPS location data and mark-recapture data from 2011 to 2014 were used to evaluate movement and site fidelity.

Analysis of dive behaviour revealed a diurnal pattern whereby turtles rested at night and were active during the day. Three of the four turtles spent a similar proportion of their time exhibiting these two behaviours. GPS data indicated a small range of movement (less than 3km from capture site). Recapture data showed site fidelity up to 960 days.

My findings are important for local scale conservation. The results of this study showed a diurnal behaviour pattern that puts turtles at particular risk of interacting with human recreational activities. Further work in this area should include more comprehensive investigation of the horizontal movements of these turtles to complement these results.

# Convention on Migratory Species / IOSEA Marine Turtle Memorandum of Understanding

***Douglas Hykle***

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The *Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia* puts in place a framework through which countries of the Indian Ocean and South-East Asia, as well as other concerned States, can work together to conserve and replenish depleted marine turtle populations for which they share responsibility. With a current membership of 35 Signatory States, including Australia, it is the primary intergovernmental instrument through which the region's marine turtle populations will be conserved over the coming decades.

The IOSEA agreement, which was concluded under the auspices of the Convention on Migratory Species (CMS) in 2001, covers six marine turtle species. The Memorandum's Conservation and Management Plan - containing 24 programmes and 105 specific activities - focuses on reducing threats, conserving critical habitat, exchanging scientific data, increasing public awareness and participation, promoting regional cooperation, and seeking resources for implementation.

The information exchange facility provided by the IOSEA website (www.ioseaturtles.org) is of particular interest to governments, NGOs and conservationists throughout the region. It offers up-to-date news, comprehensive status reports, various online databases (e.g. satellite tracking, international flipper tag recoveries, bibliography resource) and an electronic library of useful information. A comprehensive review of strengths and weaknesses in implementation, knowledge gaps, and opportunities for improvement will be presented at the forthcoming Seventh Meeting of IOSEA Signatory States (Bonn, Germany, September 2014).

That meeting will also oversee the launch of the IOSEA Network of Sites of Importance for Marine Turtles, culminating many years of intensive developmental work. The network is intended to enhance the local-to-global scale recognition of the importance of selected sites, while offering conservation benefits that are most readily achieved through a well-coordinated mechanism.

# Marine Turtle Monitoring Project: A Collaborative Research Approach in the North Kimberley

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Development of community-based management plans is one avenue through which Indigenous communities express their aspirations for the management of their marine and coastal environments. The Wunambal Gaambera Aboriginal Corporation, representing the Traditional Owner community associated with the Uunguu Native Title Determination in the remote north Kimberley, has created the Wunambal Gaambera Healthy Country Plan. The plan was developed by local Traditional Owners in a participatory planning process supported by Bush Heritage Australia and using internationally accredited Conservation Action Planning methodology. The plan identifies performance criteria for maintaining healthy sea country (including marine species and habitats), and then establishes targets for monitoring. Target 10 of the plan relates to marine turtles and dugongs and states:

> *We need to know more about where [turtles and dugongs] travel, their habitats in our country and how to look after them. Working together...using our traditional knowledge, doing surveys...will help us keep these animals healthy in our country as well as keeping our saltwater traditions strong.*

To support implementation of this target a collaborative research partnership project was established involving the Wunambal Gaambera Aboriginal Corporation, the North Australian Indigenous Land and Sea Management Alliance Limited (NAILSMA) and CSIRO to develop community-friendly, scientifically-robust, boat-based survey and mapping methods to monitor turtles on Wunambal Gaambera country. This project is part of the Northern Australia Hub of the National Environmental Research Program, which receives support from the Australian Government.

Although boat-based surveys are not currently used to monitor the distribution and abundance of marine turtles over extensive areas in Australia, there are significant advantages in doing so at local and regional scales. For example, local feeding populations in Wunambal Gaambera country comprise primarily green turtles and, in contrast, most local nesting populations are flatback turtles. The method therefore provides a mechanism for the community to gain regular, fine-scale information about local populations of interest. Additionally, the methodology is readily accessible to Indigenous rangers and can therefore be incorporated into regular patrols and work plans. Finally, standardised boat-based surveys undertaken by ranger groups across northern Australia have the potential to collectively provide regular regional assessments of the health of marine turtles in large areas of sea country that are typically data poor.

To support the implementation of boat-based surveys, CyberTracker software was used by NAILSMA to design a custom-built survey I-Tracker Turtle & Dugong Survey application which can be installed on rugged mobile devices to collect survey data in the field and to help generate maps and reports.

The boat-based survey method uses two observers placed on either side of the boat who call out all sightings of turtles and dugongs to a third person who records data using a mobile device loaded with the survey application. The boat travels slowly at ~5-6 knots along fixed transects approximately 1.0-2.5km long and systematically spaced approximately 250m apart. Environmental conditions that may affect the visibility and/or behaviour of turtles, and hence their sightability, are recorded at the beginning and end of each transect (e.g. sea state, cloud

cover, wind, glare, water clarity, tide and average depth).

Whenever possible, turtles are recorded individually and a GPS point is taken after each sighting. The following information is recorded for each observation using the survey application: perpendicular distance class from the boat (0-25m, 25–50m or 50m+); species; reproductive size class (juvenile, sub-adult, adult) and behavior. In very high density areas where this information cannot be recorded for each individual, a 'turtle counter' function can be used to record multiple individuals. When systematic transect surveys are not being undertaken (such as when travelling to or from survey areas), sightings are recorded as 'off transect' to aid mapping distribution. Importantly, CyberTracker also allows survey effort data to be automatically recorded for each patrol, such as: number of observers; distance travelled; total hours and average speed.

Initial field work for the project was completed on Wunumbal Gaambera country in May 2012. The primary aim of this trip was to trial the feasibility of boat-based surveys and to establish a line transect survey site for a local feeding population of green turtles. The method outlined above was used successfully with only minor revision needed to suit local conditions, and a survey site was subsequently established at Mary Island (13°59′38″S; 126°23′01″E). A Mary Island survey consists of a total of 7 transects running in parallel lines at least 250m apart in two strata (n=2 lines in stratum A on the northeast side of the island; n=5 lines in stratum B in a channel between the southeast side of the island and the mainland).

During this initial fieldwork, a total of 100 turtles were sighted and recorded with the vast majority (94%) identified by observers as being green turtles. Initial analysis of green turtle data yielded estimates of relative density ranging between 1.1 per km in the lower density zone to 3.4 per km in the higher density zone (weighted mean of 2.1 per km).

Subsequent surveys were completed by the Uunguu rangers at Mary Island in: June 2012 (9 turtles recorded); August 2012 (181 turtles recorded); October 2012 (56 turtles recorded); March 2013 (43 turtles recorded); and August 2013 (four surveys with 49-98 turtles recorded). The vast majority of observations were green turtles (84-100%) and only a few hawksbill turtles were sighted. The relative density of green turtles ranged from 1.4 per km (June, 2012) to 15.4 per km (August, 2012), with seasonal peaks around August. Analysis to date indicates that the most important environmental variables affecting the number of turtles sighted are water clarity and tide, with an outgoing tide yielding the highest counts.

Extensive seagrass surveys were carried out in the Wunambal Gaambera project area in August 2013 in order to identify potential long-term monitoring sites, and used a combination of live underwater video streaming, grab sampling and beach walks. No intertidal seagrass sites were found and almost no seagrass was found at all around Mary Island. These results indicate that a range of algae species support the turtle population being monitored at Mary Island. However, a significant seagrass meadow was found at an area identified by rangers and Traditional Owners where dugongs are regularly sighted. Seagrass at this subtidal site is now being monitored and assessed, which complements results for turtles and dugongs from boat-based surveys through the direct link to their food availability.

An additional aim of the project was for the tools and survey design to be shared, applied and implemented by other Indigenous land and sea managers. After the initial trial of the method by the Uunguu Rangers, the method was adopted by another Indigenous community. The Dambimangari people of the northwest Kimberley are a saltwater people with specific cultural responsibilities for dugong and marine turtle. The Dambimangari Healthy Country Plan 2012-2022 was developed by the Dambimangari Traditional Owners with support from Kimberley Land Council, the PEW Environment Group and The Nature Conservancy using a modified version of the Conservation Action Planning tool and associated Open Standards methodology to set out a vision, identify conservation targets and threats and recommend management objectives and strategies. Target 4 of the Dambimangari Healthy Country Plan (HCP) specifically refers to dugong and marine turtles and the need for survey work to support understanding of the health of the target species identified, in order to assess their status over time:

> *So far only small parts of our country have been properly surveyed and we need to make sure we record our old people's knowledge and at the same time do research jointly with scientists to get a better understanding of the health of our targets.*

The first application of the boat-based survey method on Dambimangari country was carried out in August 2012 at Montgomery Reef (15°56′34″S; 126°23′01″E). Extremely high densities of green turtles in the area were recorded using the method outlined above. A total of 2,363 turtles were recorded over four days including 2,289 green turtles and 18 hawksbill turtles with a relative density of 28.3 turtles per km. The majority of turtles were observed at the reef edge on an incoming tide. High rates of tidal flow (tidal ranges 8-9m) and water turbidity (and hence low sightability of animals) meant that survey transects were limited to shallow waters adjacent to or on the reef.

Subsequent surveys were completed by the Dambimangari Rangers in August 2013. Results were very similar to those recorded in 2012, with 2,013 turtles recorded over four survey dates with a relative density of 29.3 turtles per km. The proportion of juveniles, subadults and adults was also very similar between years, with four times more young turtles counted than adults.

These surveys demonstrate that standardised line transect methods can be applied to small-boat surveys of marine animals to monitor local density and abundance, and that boat-based surveys undertaken by community-based ranger programs are an effective means of gathering data on turtle distributions in remote localities in north Australia. Future survey work and analysis will be used to monitor local populations over time and provide an early detection mechanism for population changes. Due to the migratory nature of turtle populations, similarly designed surveys in other coastal communities across the north would greatly value-add to regional and national conservation and management objectives.

# *Narnu-Yuwa ki-Wundanyukawu* [Law for the Sea Turtle]: delivering wide ranging ecological, social and economic outcomes from threatened species monitoring

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## Introduction

In 2004 a group of researchers in collaboration with Ii-Anthawirriyarra Sea Ranger Unit (SRU) undertook a small scale research and monitoring project on West Island (Sir Edward Pellew Group) in the southwest Gulf of Carpentaria, Northern Territory, Australia. Targeting flatback turtles (*Natator depressus*) at peak nesting times (end of September beginning of October) this two week "turtle camp" has since become a fixed annual feature on the Ii-Anthawirriyarra calendar. Significantly, over this time, the event has grown in size and scope beyond all expectation and now encompasses a number of social and economic dimensions not foreseen at project inception.

A brief background to the project, the key players involved and overall scientific objectives are included below. This outline is juxtaposed against perceptions of project value as expressed by Yanyuwa and Mara Traditional Owners before some discussion of present and future challenges ensues. The discussion suggests that "turtle camp" represents a valuable model for equitable and effective collaborative research that may be applied on Indigenous estates in the southwest Gulf, across northern Australia, and potentially more broadly.

The annual camp takes place in the Yanyuwa heartland, bordering Mara lands to the northwest. The ultimate success of the venture must be attributed to the enthusiasm and support of Aboriginal Traditional Owners, who approached the project with open minds, and to the SRU which continues to grow in capacity and commitment. The Traditional Owners, SRU, researchers, NT Government and WWF Australia worked together to source funding for a project to achieve specific Wundunyuka [sea turtle] outcomes but were also active in exploring other potential benefits through an annual community camp. The professional dedication of all project partners in considering alternative cultural perspectives and working constructively towards a truly integrated and equitable monitoring and management regime for Wundunyuka ensured project longevity. Over years, these attitudes have given rise to strong and enduring relationships of mutual trust and respect. As a result, the Yanyuwa and Mara families have fully embraced the event and turtle camp today will see upwards of 70 to 80 men, women and children camped on the beach to support and share in the experience.

## Initial Project Objectives

The Borroloola region has had a long association with science and collaborative efforts for conservation. From the rescue of stranded animals in the aftermath of Cyclone Kathy in 1984, to ongoing dugong surveys and tracking, seagrass and turtle monitoring – particularly during a period of increasing sick turtles during the early/mid 2000s – Yanyuwa traditional owners and the SRU have been actively involved in all manner of habitat and species conservation initiatives. Along the way a number of positive and productive working relationships have been formed with a diverse range of environmental agencies, including Charles Darwin University (CDU) the world Wildlife Fund for Nature (WWF) and NT Parks and Wildlife. These relationships formed the basis for the flatback monitoring programme that commenced in 2004.

This project, initially funded through Commonwealth funding, aimed to establish monitoring of nightly nesting for flatback turtles at West Island, Sir Edward Pellew. Other scientific data was also collected such as sand temperatures, hatching success, and some movement data via satellite transmitters.

Additional project aims were to form long-term collaboration between scientists, Traditional Owners and Rangers. Since that time a two week census has been held every year to monitor nesting abundance of nesting flatback turtles at West Island. Data collected over this time returns an average of nine nesting turtles per night and high hatching success rates. In addition, the ongoing research programme has provided invaluable training opportunities for the SRU. Rangers have learned scientific techniques and methods in the field of turtle monitoring which also have application across a wider range of environmental conservation activities.

**Additional Benefits**

Not least of these positive outcomes is the platform that turtle camp provides for education and engagement with the wider community. The intergenerational transfer of scientific and cultural knowledge and understanding plays a vital role in the camp's overall success and takes on many forms allowing the Yanyuwa-Mara families and researchers to engage proactively with each other and younger generations in a two way learning process. Informative talks, the publication of posters and the screening of animations depicting Dreamings or Ancestral Beings, represent just a few of the outputs and tools facilitated and produced over years in conjunction with the annual camp. The overall importance of these outcomes is best articulated in the following synopsis of Yanyuwa-Mara family perceptions around *narnu-Yuwa ki-Wundanyukawu*. Key ingredients for success appear to include: a modicum of cultural sensitivity and awareness, strong community ownership and engagement, and perhaps most importantly of all, the formation of enduring relationships built on mutual respect and trust.

**A Yanyuwa Perspective on *Narnu-Yuwa ki-Wundanyukawu***

When we first began this project it was mostly science based research and some people were a bit worried about what we were doing with Wundanyuka (sea turtles). However, because we care about all the things living on our land and in our seas, we saw the value in this monitoring work. Although we have our own ways of looking after things and this was acknowledged by people we worked with, we also found that our ways and scientific ways could work together to help make sure the turtles were looked after properly.

Looking after country in this way is one of the roles we entrust to our Ranger Unit. li-Anthawirriyarra means people of the sea, "saltwater people", and our Rangers work under our guidance both independently of and in cooperation with other trusted researchers and organisations to make sure that this happens.

But this is only one of the many things we expect of our Rangers. We firmly believe that country needs people and people need country for both to stay healthy. This is what we have seen happening at Maabayj on West Island. From just a few families attending the camp at the inception we now sometimes see as many as 70 to 80 men, women and children camping on the beach and working with the rangers and researchers. Some of the kids have never been to their country or have only visited occasionally. They don't fully know what their country means or what their responsibilities are. Turtle camp gives us another opportunity to teach them narnu Yuwa (the Law) and for them to learn who they truly are and to feel good about themselves. These are just some of the positive social outcomes.

Over the past six or so years, more and more families are attending turtle camp. We now see the proper ngimirringki (owners for father's country) and jungkayi (custodians for mother's country) sitting and talking on the beach together over times past and times to come. This is good for the kids because they have a chance to learn their traditions and how they fit in with their kin and country. This is also good for older people who have spent their lives travelling across their land and sea. For example, some of our bardi bardi (older women) have composed three new songs for the islands over the past two years at turtle camp. Sadly, fewer and fewer songs have been made over the past years but turtle camp shows us that our culture is still strong and we still have a strong future. All we need to do is put things back in context and the context is country. When we think and work this way, we find our culture reenergised and this gives us confidence into the future.

It is interesting to notice that the more we work together (science and Yanyuwa-Mara way) the more and more people become interested in what we are doing. For the past three years we have had kids from the Community Education Centre (CEC) come out to turtle camp for a couple of days to share in the research work and the overall experience. They will be coming again in 2014. In addition, our Rangers give presentations at the CEC during the year and we also have a growing junior ranger programme we call li-Jawina li-Anthawirriyarra or little saltwater people still

learning. The CEC is planning to integrate turtle camp and the junior rangers more into the school curriculum. In addition, it has been a welcome surprise to find that many other non-Aboriginal Borroloola community members have embraced turtle camp and the whole ranger program. These too are also positive social outcomes.

Over the years we have watched as our kids transform out on the island. They become interested, engaged and respectful. They follow the old people, the Rangers and the researchers around asking questions. Some have been at turtle camp since it started and they are still fascinated and sometimes under your feet as you go about your work. They are our future owners and custodians and as we build on this and other work we know that some of them will also be our future Rangers.

We never take our work for granted but sometimes we forget how special and unique the turtle camp experience is. A lot of what we are doing now is with a view to building future financial independence and we are currently trialling the inclusion of paying guests to a portion of the turtle camp to financially support the continuity of the annual event. Since 2012 we have been overwhelmed by the interest and the positive feedback. After the 2012 trial, we have sought and been successful in obtaining funds from the Community Benefits Trust from McArthur River Mines and the Commonwealth Government's Indigenous Protected Area program to buy and install permanent luxury eco tents. The guests now experience the bush and the turtle camp and also enjoy good accommodation, toilets and showers as well as three square meals a day. We take them on boat tours and the bardi bardi hold song sessions during the day and teach them to dance at night. We also have scientific talks from the researchers and watch DVDs about the Dreamings that run across our country. After the dancing in the evening, we take our visitors down the beach to show them our research work and to let them observe from a safe distance the Wirndiwirndi (flatbacks) laying eggs.

## Conclusion

In the final analysis, it appears that the success of this collaborative project ultimately resides in a shared concern for the health of country and all the things in and on it. The relationships underpinning and sustaining all aspects of turtle camp are forged around this common cause. Given the valuable outcomes emerging out of this concern however, this brief overview represents but a starting point for a more detailed analysis of what has worked and what has not over the course of 10 years monitoring work at Maabayj, West Island. That analysis in itself will represent yet another collaborative exercise involving the Yanyuwa-Mara families, li-Anthawirriyarra Sea Ranger Unit and all the other key researchers and partners that have contributed to the success of this undertaking. Future published research in this regard promises insights into how that success might be replicated elsewhere and that is the intention of all parties involved. In the meantime, the relationships and concerns for country spoken of throughout this brief summary are best articulated in the words of a senior Yanyuwa woman with a brief introduction as follows:

One of our bardi bardi spoke these words late at night on the beach. She was walking alongside a Wirndiwirndi (flatback) who was returning to the water after nesting. We think they sum up how many Yanyuwa people feel about kin and kindred species. Wundanyuka are special to us. They have given us many things in the past and now provide opportunities for the present and the future.

*Bawuji nya-ngatha nya-nganji*

(you have finished my kinsman)

*Wingkayarra yalayka ja-wukuku*

(go now quickly, my senior mother's mother)

*Janda-yanynymanjiyinku*

(the sea laps the shore for you)

*Kurda! Ka-warrka kurdandu bara…*

(Oh you dear one! You have crawled so hard)

*…Marnaji ngarna wambu barra yinda wingkayarra kajikaji*

(I will remain here and you will quickly go)

*Bawujiiiiiiiiiiiiiiiiiiiiiiii!*

(Farewell)

(Roddy Harvey with translation by Associate Professor John Bradley.)

# Potential Applicability of Persuasive Communication to Light-Glow Reduction Efforts: A Case Study of Marine Turtle Conservation

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Coastal lighting poses a significant threat to marine turtles due to their reliance on brightness cues for sea-finding. Effective lighting management requires widespread support and participation, yet engaging the public with light reduction initiatives is difficult because light at night is integral to modern society. We present a case study from Queensland, where a light reduction campaign was initiated in 2008 to protect loggerhead turtles near the globally significant nesting beach of Mon Repos. Semi-structured questionnaires explored community beliefs about light reduction, and evaluated the potential of persuasive communication techniques, based on the Theory of Planned Behavior (Ajzen, 1991), for increasing community engagement with light reduction.

Respondents had moderate to strong intentions to reduce light, and personal norms were the strongest predictor of behavioral intention. Together with significant differences in belief strength between compliers and non-compliers, we suggest that the strongest persuasion potential for future communications may result from targeting the beliefs that reducing light leads to 'increased protection of local turtles' and/or 'benefits to the local economy', in combination with an appeal to personal norms. Selective legislation and commitment strategies may also be useful approaches to increase community light reduction. As the significance of artificial light as a pollutant continues to gain attention, this study provides a starting point for necessary further research into effectively managing light at night.

# Western Cape Turtle Threat Abatement Alliance: Indigenous Rangers Driving Collaboration for Marine Turtle Protection in Cape York

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Indigenous Land and Sea Rangers from communities along the west coast of Cape York have been monitoring turtle populations and controlling threats for many years. Much of this has been done in isolation from other groups. In late 2013, the Northern Peninsula Area Regional Council, Mapoon Aboriginal Shire Council, Napranum Aboriginal Shire Council and Pormpuraaw Aboriginal Shire Council made a formal commitment to work together on a regional approach to monitoring and threat management of endangered flatback, olive ridley and hawksbill turtles. They did this by forming the Western Cape Turtle Threat Abatement Alliance to support Councils to manage turtle conservation locally, while sharing resources and coordinating works. The locally-driven Alliance empowers groups to make management decisions based on local knowledge and experience supported by partnerships with a range of scientific and technical experts.

Through support from Cape York NRM and Ghost Nets Australia the Alliance has engaged a full-time coordinator to work across the ranger groups to address regional threats to turtles at a landscape scale, to support the efficient use of funding across groups for on-ground work for turtle protection, align data collection, engage scientific advisors and facilitate ranger exchange and mentorship.

A key focus area has been feral pig management. Pig predation on turtle nests and hatchlings on the west coast of Cape York has been identified as perhaps the greatest threat to local nesting populations with predation rates of between 70-98% observed in many locations. The Alliance has allowed ranger groups to coordinate feral pig culls to ensure that efforts support local ownership of management, make best use of funding and improve turtle hatchling survival.

Other key priorities include the development of standardised data collection tools and negotiation around data sharing and management protocols within the Alliance, establishment of permanent ghost net monitoring sites, and the development of nationally accredited turtle monitoring units for indigenous rangers.

By working together, Indigenous ranger groups responsible for on-ground works are given a greater voice in determining funding and management priorities for protection of local marine turtle populations nesting on the west coast of Cape York Peninsula.

# Assessment of Feral Animal Predation Associated with Flatback Nesting Beaches at Mundabullangana Station

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Feral animal predation on marine turtle nests is recognised globally as a threat to hatching success. The red fox is widespread along the coastline of the Pilbara region in Western Australia which is an important nesting area for a number of marine turtle species. To better understand the extent of fox predation and assist in threat mitigation decision making we undertook a nest monitoring pilot study during the 2013-14 nesting season at Mundabullangana Station, located approximately 70km south of Port Hedland. This site is a significant flatback rookery with an estimated 1800 nesting females per year (Pendoley et al, 2014). To determine the level of predation, remote camera traps were focused upon new nests shortly after laying to monitor nest predation during the incubation period until hatching. The numbers of eggs were counted prior to camera placement so that survivorship comparison could be made between predated and undisturbed nests. A sand plot study to assess fox activity in the area was undertaken in conjunction with the camera traps. Due to severe cyclone activity in the area the study was discontinued 7 to 10 days prior to hatchling emergence however preliminary data for the incubation period was collected. Foxes were seen to dig into late term nests which were then scavenged upon over the next 48 hours by native and exotic animals. The activity of foxes captured by camera traps was seen to increase as the nesting season progressed indicating potential predation threat upon hatchlings and nests. These results indicate the need for further study to provide information on fox behaviour and the impacts upon marine turtle nesting activities.

# Commonwealth Protection Framework for Marine Turtles in Australia

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The Department of the Environment is the lead Government agency for developing and implementing national policy, programs and legislation to protect and conserve the natural environment. Australia meets its international obligations to these conventions principally through the EPBC Act. It does so by being a signatory to many international partnerships, agreements and initiatives.

Domestically, the Department of the Environment undertakes the management and conservation of turtles through a variety of policy guidance documents and programmes.

One such policy document is the 2003 Recovery Plan for Marine Turtles, which is being remade, with input from State and Territory Government agencies, Indigenous representatives, scientists and conservation non-governmental organisations. Other policy documents include Threat Abatement Plans of which there are currently four that specifically identify threats to turtles.

Recently, the Australian Government issued a joint statement announcing the delivery of a $7M programme to manage feral pigs and other predators impacting on turtle nesting and hatchling success. This programme complements the $5M election commitment “the Dugong and Turtle Protection Plan (DTPP)”, which was one of three components of a larger election commitment aimed at the GBR. The DTPP has been secured for delivery of the Plan through the Reef Trust. The Dugong and Turtle Protection Plan is a component of the Reef 2050 Plan.

# Satellite Tracking of Hawksbill Turtles on Groote Eylandt

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Groote Eylandt, located off eastern Arnhem Land in the Gulf of Carpentaria, is the third largest island in Australia, and the associated archipelago includes over 40 smaller islands. Groote Eylandt and its satellite islands have outstanding conservation values, including internationally and nationally significant sites for nesting marine turtles. The islands support the densest areas of marine turtle nesting in the Northern Territory, and are especially significant for green and hawksbill turtles. The islands within this site are part of the Anindilyakwa Indigenous Protected Area (IPA) and are managed through a series of management plans dating back to 2006. Indigenous rangers based at Alyangula, Umbakumba and Angurugu undertake a range of management activities including survey and removal of marine debris, protection of turtle nesting areas, collaborative biodiversity surveys with scientific staff from NT Government, NT Fisheries and Charles Darwin University. Anindilyakwa Rangers have conducted 30 sea patrols in the last 12 month period which incorporated retrieving ghost nets and marine debris from the nesting beaches on Groote Eylandt. These activities are fundamental to protecting important habitats for marine turtles, and resulted in the release of 17 mature turtles from ghost nets.

In 2009-10, 10 adult female hawksbill turtles nesting on Groote Eylandt were equipped with Fastloc GPS and Argos satellite transmitters to investigate habitat utilisation during the inter-nesting and foraging period, along with migratory behaviour. During the breeding season, females predominantly remained near their nesting site in a restricted area, although some individuals displayed broad movements (median distance = 0.5km). All adults migrated to foraging grounds located on the Australian continental shelf from northern Arnhem Land to the southern Gulf of Carpentaria, with post-nesting migrations ranging from 70.8 to 568.0km. The distribution of those foraging grounds demonstrates that the Gulf of Carpentaria supports critical developmental and feeding areas for hawksbill turtles.

Turtle monitoring is benefiting students and community by embedding knowledge, numeracy, literacy and scientific learning in real, practical activities that are relevant to engaging to the students and their local community. Four indigenous schools also attend classes on country from local experts, rangers and vocational educational trainers and school teachers. These opportunities allow students and community to build new relationships with and learn from role models from their communities. It also improves leadership and allows students to be mentored. Hawksbill monitoring was conducted in September 2013 at North East Island in conjunction with the ranger program, where children were provided training and the opportunity to assist rangers with tagging hawksbill turtles to facilitate greater understanding of migratory patterns. This highlights the important role that Indigenous people have through IPAs and other protected areas play in protecting migratory species as well as wildlife that are resident in IPAs.

**Figure 1.** Releasing a turtle from a net (Phillip Mamarika).

**Figure 2.** This is one of five hawksbill turtles caught on the same beach, on the same day and released alive (Jocelyn Yantarrnga).

# Darkness is the Best Lighting Management Option at Turtle Nesting Beaches

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Past guidance regarding turtle friendly lighting for marine turtles was based on studies in Florida which found low pressure sodium vapour lights were the only light not disruptive to the ocean-finding behaviour of *Caretta* hatchlings but they were disruptive to the ocean-finding behaviour of green and leatherback hatchlings. Electronic lights (amber LED lights) mimic the spectral properties of low pressure vapour lights. Fritsches (2012) established that eastern Australian *Caretta* behave differently to the Florida *Caretta,* with our *Caretta* hatchlings responding to the low pressure sodium vapour light frequencies. Arena trials on Queensland beaches show significant disruption of ocean finding behaviour of *Caretta*, *Chelonia* and *Natator* hatchlings in the vicinity of all standard street light types including low pressure sodium vapour lights and amber LED lights. A recent University of Queensland post-graduate study, showed that while dim light from a single amber LED bollard light may have minimal impact on loggerhead turtle hatchlings, the cumulative impact of multiple amber LED lights can be extremely disruptive. Altered ocean finding behaviour has been recorded for adult *Natator* up to 18km distant from a brightly illuminated industrial plant.

In a re-assessment of the ocean-finding behaviour of marine turtle hatchlings, Limpus and Kamrowski (2013) established that hatchlings are not attracted to bright lights but rather they orient towards the horizon at the lowest angle of elevation to their view point and move away from elevated dark horizons. This natural ocean-finding behaviour is disrupted when surrounding lighting masked the turtle's ability to see the distant horizons. We now realise that for marine turtles breeding in Australia, there are no light types that should be promoted as "turtle friendly". This applies equally to low pressure sodium vapour lights and amber LED lights.

Darkness remains the best management option in the vicinity of turtle nesting beaches. Every effort should be made to eliminate/turn off unnecessary lighting during turtle breeding seasons. Where lighting is essential, lateral spillage of light illuminating wind borne salt spray and clouds should be reduced by substantial vertical shielding of the lights. Reflective surfaces can be managed to reduce sky glow.

Fritsches KA (2012). Australian loggerhead sea turtle hatchlings do not avoid yellow. *Marine and Freshwater Behaviour and Physiology* **45**, 79-89.

Limpus CJ, Kamrowski RL (2013) Ocean-finding in marine turtles: the importance of low horizon elevation as an orientation cue. *Behaviour* **150**, 863-893.

# Predator Reduction Strategies for Protecting Loggerhead Turtle Nests at Wreck Rock Beach in Queensland

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The loggerhead turtle (*Caretta caretta*) is an endangered species and Australia's eastern beaches support the only significant stock in the South Pacific Ocean. Wreck Rock beach, just south of Agnes Water at the southern boundary of the Great Barrier Reef Marine Park, is considered to be the second largest mainland loggerhead nesting site (to Mon Repos). Over the past decade, more than 810 loggerhead turtles have nested along this 22km stretch of beach. However, over the past few years it has been estimated that as much as 80-90% of the clutches are suffering from predation by native and feral predators (pers. comm. Colin Limpus). Yet with an apparently successful fox baiting program in place, there appears to be an increase in the occurrences of native goannas predating on nests. Predation is a major threat to loggerhead hatchling survival not only at Wreck Rock beach, but for many turtle species on a number of nesting beaches throughout Queensland. A management solution or intervention is urgently required.

This project aimed to assess and reduce predation on loggerhead turtle clutches at Wreck Rock beach by determining the effectiveness of a predator exclusion device, which was designed by Dr Colin Limpus. The device trial was undertaken during the 2013-2014 nesting season whereby 58 nests (32 with a device and 26 as controls) were monitored daily for predator activity. Sensor cameras were also used to determine predator species present and number of visits. Twenty-five nests were monitored for hatching success. This data is crucial for understanding the impact of predation on the local marine turtle population, and will be used to develop sound conservation management strategies to ensure the long-term survival of loggerhead turtles not only for Queensland but as a stronghold for the entire South Pacific Ocean.

# Sand Temperatures at a Major Flatback Rookery Suggest a Masculinising Trend in Recent Decades

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Quantifying primary sex ratios at breeding sites is essential for assessing how global warming will influence the population dynamics of species with temperature-dependent sex determination (TSD). Process-explicit (mechanistic) models can accurately estimate primary sex ratios but require the resolution of the key physiological parameters that influence sex determination. Further, models need to be validated by testing their predictions against empirical data from field nests. To address these goals we conducted incubation experiments on flatback sea turtle (*Natator depressus*) embryos from a large winter-nesting rookery at Cape Domett in the east Kimberley region of Western Australia. A TSD model fitted to data from laboratory experiments and field nests indicated that the pivotal temperature producing equal sex ratios was approximately 29.4°C. Back-switch experiments, where eggs are moved between male and female-producing temperatures for different portions of development, revealed that the thermosensitive period (TSP) when gonads differentiate into testes or ovaries, occurs between 43% and 66% of development to hatching. Taken together, these new physiological data allowed us to accurately estimate the sex ratios from a small sample of nests where the sex-ratio of late-stage embryos was measured in 2012. Integrating the physiological information with sand temperatures reconstructed from 23 years of historical climate data, show that male biased sex ratios are likely at Cape Domett if the TSP falls during the Austral winter. Annual variation in the simulated sand temperatures increased from 1990-2013, with cooler winters producing conditions that favoured male hatchlings for longer periods. The same model projected to 2030 and 2070 suggests that female-biased primary sex ratios will become more prevalent over time. Our results show that accurate modelling of primary sex ratios depends on quantifying the thermal biology of embryos and on parameterising mechanistic models of sand temperatures with site-specific climate data.

# Looking to the Future by Learning from the Past: Implementing Adaptive Management into Marine Turtle Surveys

***Dorian Moro***

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Chevron Australia has been monitoring flatback turtles (*Natator depressus*) at Barrow Island for almost 10 seasons. In 2009, the Western Australian Government gave conditional approval for Chevron to develop the Chevron-operated Gorgon Project on Barrow Island, where it had an existing oil operation since the 1960s.

To support its environmental impact monitoring, Chevron Australia developed a Long-term Marine Turtle Management Plan to frame and direct how it would monitor the impact of the development on flatback turtles. This monitoring program includes several large-scale projects which were developed within an adaptive management framework.

With five years of baseline and almost five years of post-baseline data now available on flatback turtles using Barrow Island to nest, Chevron Australia now has an opportunity to review this long-term dataset to understand the implications of the trends in biological parameters found to date. Importantly, like any large-scale ecological program, it is timely to reflect on the current status quo of the monitoring program, and how it should use the information gained to inform on future monitoring practices. This is an important element of adaptive management in wildlife ecology: using lessons from the past to inform on future practice. However, does adaptive management have a place in impact monitoring within a highly regulated environment? Results from the Gorgon Project Marine Turtle Program will showcase flatback turtle population information gained across various monitoring projects off Barrow Island based on the requirements in the Long-term Marine Turtle Management Plan. The application of adaptive management to define the future state of the marine turtle monitoring program in this Plan needs to consider progressing a monitoring program that can be flexible, targeted to address current thinking and risks, and yet remain in compliance under environmental commitments.

The Gorgon Project is operated by an Australian subsidiary of Chevron and is a joint venture of the Australian subsidiaries of Chevron (47.3 %), ExxonMobil (25 %), Shell (25%), Osaka Gas (1.25%), Tokyo Gas (1%) and Chubu Electric Power (0.417 %).

# Supporting Indigenous Communities Across Queensland for Sustainable Turtle and Sea Country Management

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Community based management of their turtle populations and sea country is a key aspiration of many Indigenous communities throughout Queensland. There are numerous advantages to this approach: including on-ground action and traditional and local knowledge and local capacity, and challenges: lack of resources, capacity, and time, confusion over native title rights in relation to traditional hunting, lack of clear governance and lack of information on turtle populations. In order to effectively manage marine resources, traditional harvest and threats to both nesting and foraging turtles, Indigenous rangers and community groups across Queensland require information regarding the status of turtle populations and if these populations are declining, increasing or remaining stable.

In response to this requirement, the Department of Environment and Heritage Protection, Threatened Species unit has been working on an Indigenous turtle and dugong management program for the last two years. The program aims include: Create partnerships in sustainable management of turtle and dugong, support Indigenous authority in regards to sea country management, assist Indigenous rangers engaging with communities to influence hunting and management practices and develop increased capacity for turtle monitoring and conservation activities on country by Indigenous rangers.

Current achievements of the program include: first ever turtle satellite tagging of olive ridley and flatback turtles in Pormpuraaw, Western Cape, 13 Indigenous rangers trained as Conservation officers with limited powers under Queensland's Nature Conservation Act, development of community based management plans for sustainable management of turtle and dugong, increased monitoring of both nesting and foraging turtle populations in communities and also through two Indigenous ranger turtle monitoring training camps, delivery of turtle and dugong conservation and biology training and seagrass monitoring training across 28 communities and the alignment of turtle monitoring methodologies with the Torres Strait Regional Authority's turtle monitoring program.

A vital aspect of the current success of this project has been through conservation and biology sustainable management training whereby information is presented on current scientific best practice, with the communities themselves taking the lead on the support utilised and hunting rules and regulations that they want to have put in place.

Key challenges and lessons from this program have been: Short term funding (two years), challenge of consistency within both government and community, accessing hunters within community, challenges associated with consensus building and agreement, challenges with compliance and enforcement and education around community based management plans and the long term sustainability of both the management and monitoring programs.

# Monitoring and Managing Marine Turtles on Barrow Island Nature Reserve

***Kimberly Onton, Brad Daw, Peter Kendrick, Paul Connolly, Wesley Manson, Misty Shipway and Catherine Rummery***

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## Introduction

The Department of Parks and Wildlife Western Australia (Parks and Wildlife) established a full-time management presence on Barrow Island Nature Reserve in 2009 as a requirement under the State Agreement for the Gorgon Gas Development. This has provided a unique opportunity to record marine turtle activity at the island's regionally significant green (*Chelonia mydas*) and flatback (*Natator depressus*) turtle rookeries year round, as well as to develop protocols for working alongside the oil and gas industry who also occupy and monitor the island's environmental values.

## Background

Barrow Island is located 56km off the northwest coast of the Western Australian mainland. It has been a 'Class A' nature reserve since 1910 and is surrounded by marine conservation reserves gazetted in 2004. Parks and Wildlife oversees the monitoring and management of the conservation estate and its wildlife, which includes implementation of the *Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-2017* (DEC 2007) and *Barrow Group Nature Reserves Management Plan* (DPaW 2015). Management strategies in these plans pertaining to turtles include mitigating impacts, monitoring turtle nesting activities, facilitating research, educating reserve users and maintaining a turtle mortality database. The former Department of Conservation and Land Management commenced a marine turtle tagging program in the 1980s which has continued periodically over the years since with a significant contribution from Barrow Island oilfield personnel.

Barrow Island has been home to Australia's largest onshore oil field since 1967 and in 2009 the Gorgon Gas Development commenced construction. Chevron Australia Pty Ltd is the current operator of these ventures. An environmental approval condition of the Gorgon Gas Development was to develop and implement a Long-term Marine Turtle Monitoring Plan to ensure impacts of the development on marine turtles are monitored and managed. A Marine Turtle Expert Panel was established to provide independent advice on marine turtle monitoring and management.

## Strandings

The Parks and Wildlife marine turtle program on Barrow Island includes responding to stranded turtles. For the purposes of this program, stranded turtles are defined as turtles that are injured, show signs of compromised health or are deceased from natural or anthropogenic causes. Barrow Island has an extensive coastline and a diverse work force of government and industry personnel that regularly traverse the coast, resulting in a high probability of detection of stranded turtles. To ensure consistency in reporting across the work groups, a procedure has been developed for responding to stranded turtles. A marine turtle field guide, developed collaboratively, covers turtle identification, injury diagnostics and stranding response procedures. Parks and Wildlife personnel are notified of all strandings and when there are signs that a turtle may have been impacted by a non-natural event, a joint assessment with Chevron Australia personnel is undertaken. The Gorgon Gas Development is required to report all marine turtle mortalities and injuries in accordance with State and Commonwealth government environmental approval conditions. Live turtles are relocated or euthanised as required and dead turtles are marked with spray paint to ensure they are not reported or recorded more than once.

Between November 2009 and August 2014, 337 stranded turtles were reported on Barrow Island. The majority of these were green turtles (83%) with the remainder comprising hawksbill (3%), flatback (2%), loggerhead (1%) and unknown species (11%). Most turtles were female (40%) or of unknown sex (57%). Of the green turtles, two distinctive size classes based on curved carapace length measurements predominated: adult size between 850 and 1050mm and juveniles between 350-500mm (Figure 1).

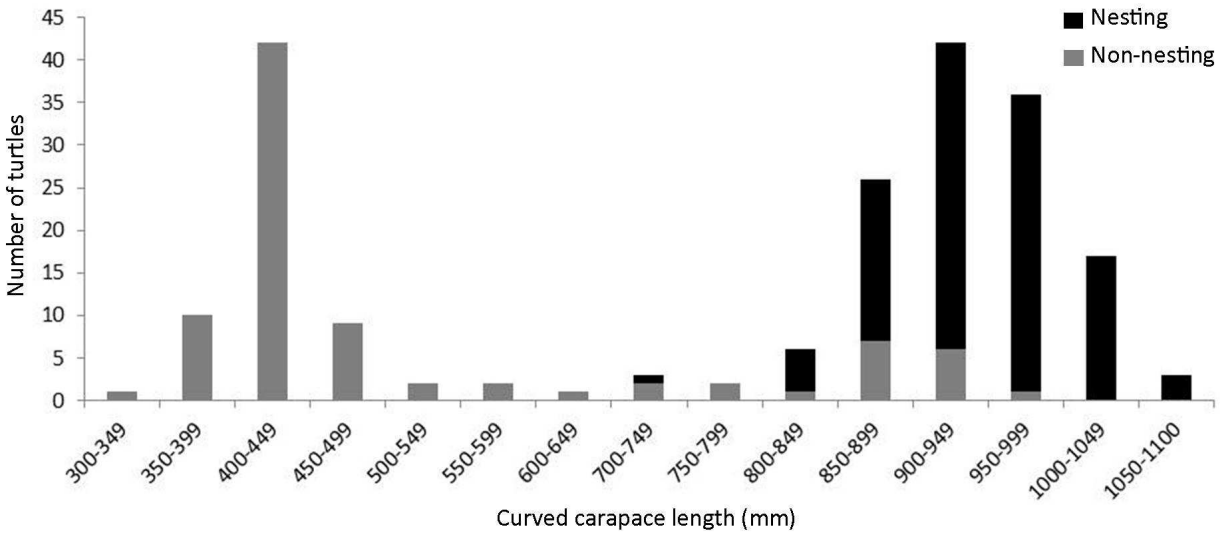


**Figure 1.** Curved carapace length of stranded green turtles measured on Barrow Island Nature Reserve between November 2009 and August 2014 (n=202). Nesting refers to turtles known or suspected to have stranded during nesting activities (e.g. found behind dunes, entrapped in rocks returning to sea or on a nest); non-nesting refers to all other strandings.

The distribution of marine turtle strandings reveals three dominant stranding circumstances. The highest mortality of nesting female green turtles was at Tania Beach and South End (14% of all strandings, with a further 6% recorded as decomposed adults of unknown species but likely to be nesting green female turtles; Figure 2). These sites have large dune blowouts behind the primary dunes of significant nesting beaches, where nesting female green turtles likely became disoriented and exhausted whilst attempting to nest or return to the sea. High numbers of strandings involved nesting female green turtles becoming entrapped or injured in rocks upon return to the sea after nesting (19% of all strandings). This was most common at Ti Tree and White's beaches due to the extensive exposed limestone platform adjacent to these nesting beaches. Of the stranded turtles at White's Beach, 73% of the turtles were encountered live and were assisted to the sea by Gorgon Gas Development personnel. Stranded juvenile green turtles were common year round (26% of all strandings). Of these, 44% were observed in the expansive shallow waters of Bandicoot Bay on the island's south coast. Non-nesting adult turtles made up only 6% of all strandings. When a fresh, easily accessible carcass was encountered, attempts were made to either undertake a field necropsy or collect the specimen for professional veterinary necropsy. Necropsy training has been delivered to both Parks and Wildlife and industry personnel. Tissue samples for genetic analysis were also collected.

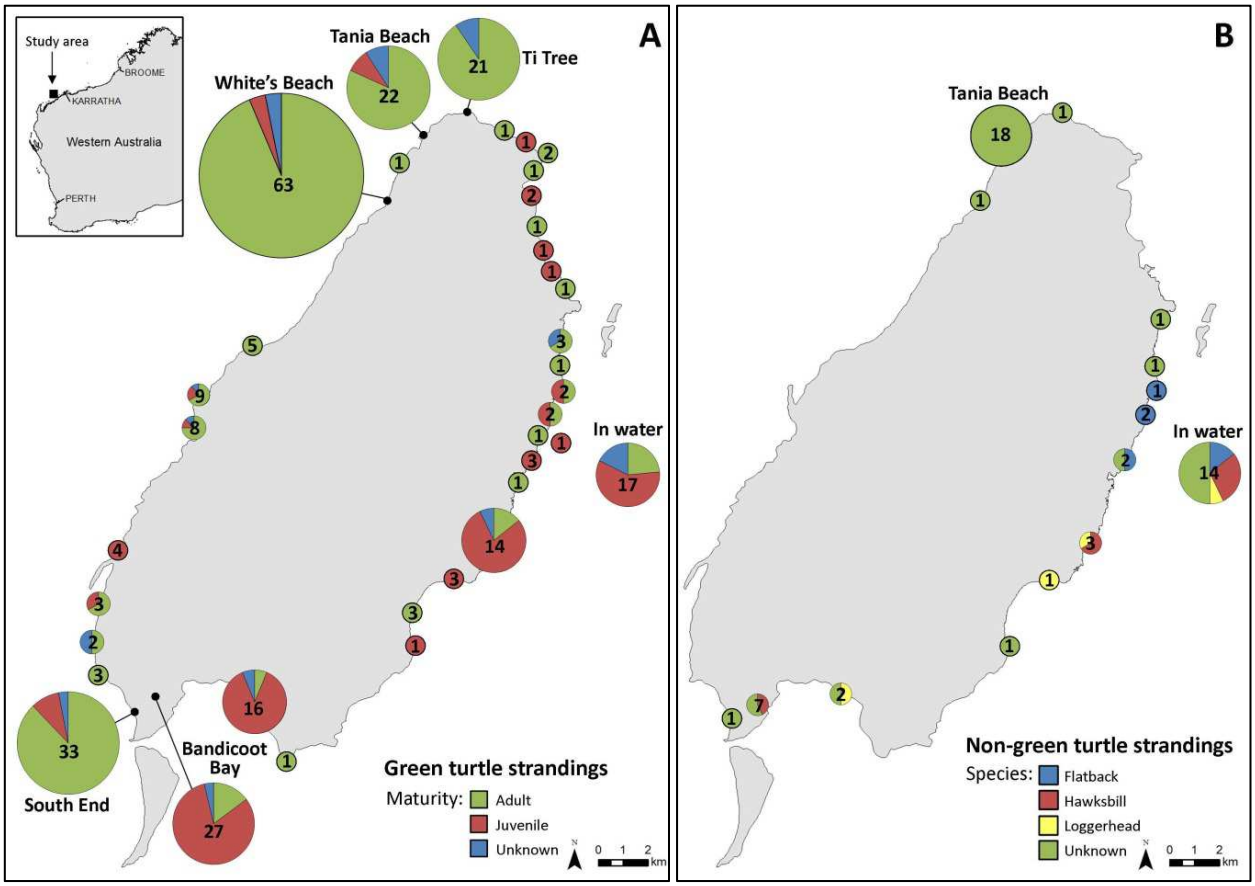


**Figure 2:** Distribution of stranded turtles on Barrow Island Nature Reserve between November 2009 and August 2014 (n=337). Pie graphs represent relative abundance of stranded turtles across sites for A) green turtles only and B) all other (non-green) species combined. Numbers within the graphs indicate sample size.

## Tagging

Parks and Wildlife personnel also tagged turtles for population studies. Having a year-round presence on the island provided an opportunity to take advantage of the seasonal low tides that exposed the extensive shallow tidal flats off the east and south coasts of Barrow Island. Many adult and juvenile turtles were tagged as they basked in the shallows where they are less mobile and easy to capture. A total of 93 turtles were tagged basking between October 2011 and August 2014, including 39 juveniles and 21 adult males, making this a safe and relatively easy means of obtaining life history information for these lesser-known life stages and investigating population dynamics of resident turtles.

These programs are intended to be further developed in the future with the aim of continuing to work collaboratively with industry to enhance our knowledge of the marine turtle populations inhabiting Barrow Island Nature Reserve and its surrounding waters.

## References

DEC (2007) Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007-2017 Management Plan No. 55. Department of Environment and Conservation, Perth, Western Australia.

DPAW (2015) Barrow Group Nature Reserves Management Plan. Department of Parks and Wildlife, Perth, Western Australia.

# The Argos Satellite Telemetry (Global) System for Wildlife Tracking and Data Collection

***Guan Oon***

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Collecte Localisation Satellites (CLS) is a French company based in Toulouse that manages and operates the *Argos* global data collection and location system. The *Argos* system started in 1978 under a joint agreement between the United States National Oceanic and Atmospheric Administration (NOAA) and the French Space Agency (Centre National d'Etudes Spatiales (CNES)) where this agreement has been extended to the European Organisation of the Exploitation of Meterological Satellites (EUMETSAT) and the Indian Space Research Organisation (ISRO) where operationally, this translates to NOAA, Metop and Saral satellites being able to receive transmissions from *Argos* platform transmitter terminals (ptts) and also to transmit user commands to *Argos* platform transceiver terminals.

The historical and core *Argos* applications are in the fields on meteorology, oceanography, biology-wildlife tracking or any application where monitoring of the environment via satellites are required where all users are either from government-scientific and/or research organisations.

In addition to *Argos*, CLS operations and services extends to space-based oceanography, maritime security, oil spill detection, tracking of commercial fishing vessels and ships and turnkey solutions for Maritime and Fisheries Authorities.

In terms of biology-wildlife tracking, in Australia and New Zealand; there are approximately 110 *Argos* programs with approximately 2,000 registered ptts where this is managed by CLS Australia/Satellite Information Technology Pty Ltd in Melbourne. Out of the 110 programs, we have 25 for turtle tracking (species behaviour and protection) with a total of 300 ptts from four certified *Argos* ptt manufacturers.

The technological evolution in the last decade has seen smaller ptts, increased positioning accuracy (Doppler and GPS), increase in the volume of transmitted sensor data such (dive count-depth-temperature-pressure-salinity) together with reduced latency; whereas from a cost perspective, daily transmission rates (in Euro currency €) has been unchanged since 2011.

The presentation will highlight some of the aspects above and also show simple and secured access to (all types of) tracking data and related ocean data.

# Nesting green turtle (*Chelonia mydas*) Monitoring at Maizub Kaur (Bramble Cay), Torres Strait

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Maizub Kaur (Bramble Cay) is located 24 nautical miles north-north east of Erub (Darnley Island) in eastern Torres Strait and is traditionally owned by the Erubam Le people. Maizub Kaur is an important green turtle (*Chelonia mydas)* rookery providing hatchlings into the northern Great Barrier Reef green turtle population. The Torres Strait Regional Authority (TSRA) and James Cook University (JCU) are conducting research work on Maizub Kaur with the support of Traditional Owners with funding from the National Environmental Research Program (NERP). The project will both improve stakeholder understanding, capacity and skills to better manage priority species and provide valuable data that is useable and understandable to those making decisions regarding turtles.

One research trip was conducted at Maizub during December in the 2012-13 nesting season and two during the 2013-14 season (December and March). Nesting activity was low for the 2012-13 season with an average of 25 turtles arriving per night to nest. The 2013-14 season, in contrast, saw more than 600 turtles each night, with a significantly high proportion of first-time taggings. Time-lapse cameras were deployed from December to March for both nesting seasons (2012-13 and 2013-14) with the aim of gaining a longer term idea of nesting activity (i.e. over the full duration of the nesting season). Here I present patterns of nest site fidelity, remigration, and other biological measures of interest for Maizub Kaur as identified from the two sampled seasons. Additional planned analyses will include changes in beach morphology and possible implications for nesting success.

# The Leatherback Turtle (*Dermochelys coriacea*) in Western Australian Waters

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Leatherback turtles are part of the coastal marine fauna of Western Australia, although still not having any known nesting presence. The earliest record I found is *c.* 1926 from Shark Bay/Carnarvon via a photo collection, but a comprehensive search for other early records has not been made. The majority of the 150 records I now have date from mid-1970 on to the present (June 2014), and include two young of the year juveniles from unknown source rookeries. The other records appear to document the foraging presence of predominantly large juvenile to sub-adult turtles. I will discuss the sources of those records in relation to community engagement and known fishery interactions in building this data-set, the biases inherent within the data to hand, and how newer information is contributing to a better focus on conservation and management of this SE Indian Ocean population.

# Genetic Structure of the Resident *C. mydas* Population of the Grand Lagon Sud, New Caledonia

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Migratory species are known to pose a challenge for conservation strategies. Indeed, it is essential to understand the underlying ecology of a species in order to implement an efficient conservation strategy. Large seagrass habitats on the coast of the Grand Lagon Sud (GLS) of New Caledonia are home to resident green turtles (*Chelonia mydas*). This study is the first to sample *C. mydas* foraging turtles in New Caledonia and determine their origins, as no nesting occurs in the region studied. To assess the stock composition of this feeding ground, 187 foraging turtles and three nesting grounds were sampled for genetic analysis of ~800 bp mitochondrial DNA control region. The post-pelagic individuals were captured by the turtle rodeo method at five different sites within the GLS between September 2012 and December 2013. The size of the turtles sampled ranged from 48 to 108.4cm curved carapace length (mean = 56.3 ± 17.5). Exact tests of population differentiation (MCMC) and estimated $F_{ST}$ using mtDNA haplotype frequency data were compared to green turtle genetic stocks in the Coral Sea. Mitochondrial haplotype frequencies were compared to known haplotype frequencies found at rookeries throughout the Pacific to conduct mixed stock analyses (MSA) using Bayesian approaches. The results confirmed that D'Entrecasteaux Islands and Vanuatu were independent genetic stocks and indicated that the Chesterfield Islands were linked to the Coral Sea genetic stock. The most likely contributor to the GLS is the D'Entrecasteaux rookeries located north of the main island of New Caledonia. The southern Great Barrier Reef (sGBR) population is the second most likely contributor to the GLS, and multiple contributions <0.05 were found to be from rookeries situated as far as 4000km in the Coral Sea. The marine conservation policies made in New Caledonia need to consider the strong link between the foraging and nesting populations of *C. mydas* of New Caledonia and other rookeries in the South Pacific.

# Coastal Flatbacks x Oceanic Greens: a Manner of Behaviour and Ocean Currents

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Marine turtles are one of the many marine species that possess an early pelagic dispersal phase, dominated by passive drift, followed by a more sedentary coastal stage, dominated by active locomotion. The dispersal patterns of their offspring seem to shape the spatial distribution of the different turtle stocks, making the study of their population connectivity a biophysical problem. Our study aimed to verify the influence of ocean currents on the spatial distribution of green (*Chelonia mydas*) and flatback (*Natator depressus*) sea turtles from major Australian nesting beaches (rookeries). By using biophysical models, we showed that baby green turtles are exposed to ocean current pathways that lead to a broader and more oceanic dispersal, when compared to those experienced by their flatback counterparts. Our results indicate that the spatial distribution of sea turtle species and populations is strongly shaped by the ocean currents that post-hatchlings are exposed to. As such, biophysical models may be able to predict the relative importance of various feeding grounds for Australian rookeries. This type of study could enhance our ability to inform coherent conservation and research strategies, at a relatively low cost.

# Patterns of Marine Turtle Bycatch Reported in Australian Commonwealth Fisheries Logbooks, 2000-2013

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The incidental capture (bycatch) of marine turtles in fisheries is widely acknowledged as a serious threat to the survival of turtle populations around the globe. In Australian commercial fisheries, bycatch of marine turtles is regulated in each State/Territory by its fisheries management agency and in Commonwealth fisheries by the Australian Fisheries Management Authority (AFMA). All interactions with marine turtles are required by law to be recorded in fishers' logbooks and reported to the relevant management agency. For long-lived species such as marine turtles, however, bycatch data must be analysed across multiple fisheries and biologically relevant timescales (>10 years) in order to meaningfully estimate the impacts of bycatch at the population level.

The aim of this study was to identify spatial patterns of marine turtle bycatch, determine species- and gear-specific correlations, and identify priority areas for further bycatch research and mitigation in Australian fisheries. This study collected and analysed >13 years of marine turtle bycatch records in logbooks from commercial fisheries in Commonwealth-managed fisheries. All reported interactions were mapped and analysed to determine locations of possible bycatch 'hotspots'.

A total of 873 interactions between marine turtles and fishing gear were reported in Commonwealth fisheries from 2000-2013. Logbook data indicates that four fisheries representing two gear types (pelagic longlines and trawls) account for >95% of reported turtle interactions. The Gulf of Carpentaria was identified as the 'hotspot' area of highest bycatch and also had the highest proportion of 'Unidentified' turtles in any of the Commonwealth fisheries. Interestingly, leatherback turtles (which no longer nest in Australia) were the most abundant species reported in the logbooks (26% of total captures). As identification of leatherbacks is difficult to mistake, the high proportion of captures of this species demonstrates an increased need to mitigate leatherback bycatch at sea. Efforts to improve species identification by fishermen as well as enforce the use of turtle excluder devices (TEDs) in the Gulf should be prioritised.

# West Pilbara Turtle Program: A Community Volunteer Program in the Pilbara

***Carissa Rowcliffe***

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Established in 2005, the West Pilbara Turtle Program (WPTP), utilises local volunteer WPTP members to monitor marine turtle nesting activity on local beaches (Bells and Cooling Water beaches, Wickham WA), specifically trends in nest numbers, species and predation. The program is a partnership between the Department of Parks and Wildlife and Rio Tinto that brings together industry, government and the local community and raises awareness of the importance of the local beaches for marine turtle conservation. Both volunteer numbers and monitoring days have been significantly increasing over the last three years; the 2013-14 seasons saw a three-fold increase in volunteer numbers compared to the 2011-12 season. Both nest numbers and false crawls have remained stable from 2010 onwards. The presentation will compare the previous four seasons, which capture the most successful seasons for volunteer numbers, days monitored, nesting behaviour and success data. The presentation will also address the benefits of utilising the local community and educating the public on anthropogenic pressures and impacts on the species; the importance of protecting threatened marine turtles; and measures taken to promote community awareness.

# Displaced Sea Turtles Return Home

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[4] Northern Territory Department of Land Resource Management, Flora and Fauna Division, Marine Ecosystems, Darwin, NT 0810
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Marine turtle research occasionally involves displacement of the animals from areas in which they were captured. Additionally, rehabilitation of debilitated turtles often involves long term retention and displacement at the time of release. Therefore it is important to understand the consequences of displacement. We relocated foraging green turtles (n = 51), loggerhead turtles (n = 30) and olive ridley turtles (n = 2) from their capture sites in north-eastern Australia and investigated their post-release movements using satellite tags. We estimated some turtles were displaced outside their pre-capture habitats whilst others were not displaced (released within their original home ranges). Regardless of displacement treatment and retention days, seventy nine turtles (95%) of the study animals were observed to have returned to their areas of capture. One rehabilitated olive ridley turtle moved toward to its capture site after a 117km displacement but did not approach any closer than 18km away from its capture site. The remaining three turtles also travelled toward their capture sites but satellite transmission ceased while they were traveling in a fairly straight line, suggesting their post-release phase had not been completed at the time of last transmission. We found that the efficiency of turtles' navigation in finding their pre-capture habitats was unaffected by the displacement treatment, the retention period or the location of the study sites. We also found that both the displaced and non-displaced turtles re-established similar-sized home ranges, indicating that displacement did not appear to cause disorientation upon arriving in the pre-capture habitat. We conclude that displacement for research and rehabilitation purposes is unlikely to disturb wild marine turtles in their selection of foraging habitats.

# Incubation Temperature, Morphology and Performance in Flatback Turtle (*Natator depressus*) Hatchlings from Mon Repos, Queensland

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Sea turtles rely on the physical environment to incubate their eggs, and require temperatures between 24°C and 33°C for successful development of embryos. Incubation temperature has also been shown to affect hatchling attributes such as emergence success, size and locomotor performance in green, olive ridley and loggerhead turtles. We investigated the effect of incubation temperature of *in situ* nests on hatching and emergence success, scute pattern, mass, size and locomotor performance in the flatback turtle (*Natator depressus*). Flatback turtles differ from other sea turtle species in a number of life history traits – they produce larger eggs and hatchlings for their size, and they lack the oceanic development stage present in all other sea turtle species. Between 2010 and 2012 we monitored the temperature of ten *in situ* *N. depressus* nests. We calculated hatching and emergence success for each nest, and measured the mass, width, length, scute pattern and locomotor performance of hatchlings that emerged. The mean incubation temperature of the nests ranged from 27.6-29.6°C. We found positive correlations between mean incubation temperature and hatchling length ($R^2 = 0.58$, $p = 0.02$), self-righting propensity ($R^2 = 0.52$, $p = 0.01$), mean swim thrust produced ($R^2 = 0.44$, $p = 0.03$) and proportion of time spent power-stroking ($R^2 = 0.44$, $p = 0.03$). Thus, incubation temperatures at the lower edge of the viable range for embryonic development have the potential to affect hatchling survival. The nest temperatures we observed were low compared to other sea turtle studies, so it would be interesting to collect data from *N. depressus* nests that have experienced higher temperatures to determine whether there is a similar decrease in hatchling quality at high incubation temperatures.

# Post-Nesting Migration from an Important Flatback Rookery, Deliverance Island, Australia

***Justin Smith[1], Mark Hamann[1], Mariana Fuentes[1,2], Colin Limpus[3] and Shane Preston[1]***

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Previous research regarding flatback turtle (*Natator depressus*) movement patterns within Australia has been limited to tag return data to infer species movement. Advances in satellite telemetry have enabled insight in understanding the spatial and temporal movement of marine turtle species. Satellite telemetry has evolved through the years, now providing accurate ecological information of animal location. Recent research has indicated that like other sea turtle species, flatbacks are capable of movement over vast spatial scales, expressing high site fidelity to foraging habitats and nesting grounds. With little information available regarding movement patterns of flatbacks, it is important to address species ecology and demographics in order to understand and apply management for an endemic species.

The aim of this study was to determine the spatial and temporal movement characteristics of nesting flatback turtles within the Gulf of Carpentaria and Western Torres Strait population unit. Eleven female flatback turtles were tagged with fastloc GPS satellite tags at Warul Kawa (Deliverance Island), an important flatback rookery, over two nesting seasons (2012/13 – 2013/14). Data shows a sporadic dispersal pattern of 10 individuals, with one tag failing pre-migration. No two turtles followed the same dispersal pattern, demonstrating inhabitancy throughout the Torres Strait, the Gulf of Carpentaria, Northern Territory and Western Australia. Displacement ranged from 1km-1676km from the nesting beach. Interestingly, two turtles travelled into Indonesian waters, the first observation for the species outside Australian waters and one turtle travelled >1600km to reside in northern Western Australia. These results emphasise the large spatial range from this population subset, suggesting the existence of possible occupation outside national waters and across State and Territory boundaries.

# Responses of Heat Shock Genes in Loggerhead Turtle Embryos (*Caretta caretta*) Exposed to Thermal Stress

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The survival and viability of sea turtle embryos is dependent upon favourable nest temperatures throughout the incubation period. Consequently, future generations of sea turtles may be at risk from increasing nest temperatures due to climate change, but little is known of how embryos respond to heat stress. Heat shock genes are likely to be important in this process because they code for proteins that prevent cellular damage in response to environmental stressors. This study provides the first evidence of an expression response in the heat shock genes of embryos of loggerhead sea turtles *(Caretta caretta)* exposed to realistic and near-lethal temperatures (34°C and 36°C) for one or three hours. We investigated changes in the expression of *Heat shock protein 60* (*Hsp60)*, *Hsp70*, and *Hsp90* in heart (n=23) and brain tissue (n=23) in reaction to heat stress. Under the most extreme treatment (36°C, 3 h), *Hsp70* increased expression by a factor of 38.8 in heart tissue and 15.7 in brain tissue, while *Hsp90* expression increased by a factor of 98.3 in heart tissue and 14.7 in brain tissue. Our findings indicate that both *Hsp70* and *Hsp90* are useful biomarkers for assessing heat stress in the late-stage embryos of sea turtles. Our results can be used for future studies of variation in the thermo-tolerance response of sea turtles at clutch and population levels.

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# Post-nesting migratory movements and foraging grounds of flatback turtles *Natator depressus* in response to tidal fronts in northern Western Australia

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State-space models are now being used to understand the movement behaviour of many species of marine megafauna and provide an objective determination of ecologically significant areas. This approach is useful for examining potential conflicts between megafauna and industrial development, particularly the offshore oil and gas industry. Flatback turtles (*Natator depressus*) are a species for which recognition of the potential for conflict with industry has led to relatively large-scale tracking projects but the data have not been subjected to any high level analysis and the work remains largely unpublished.

We used a state-space switching model to analyse satellite telemetry data from 11 female, flatback turtles from the Lacepede Islands, Western Australia. After nesting ceased, the turtles appeared to follow tidal fronts along the Kimberley coast - the boundary between well-mixed and stratified waters. The turtles travelled to foraging grounds on the raised carbonate bank and terrace systems of the mid Sahul Shelf in the Timor Sea in average water depths of 74 ± 12m, 135 ± 35km from shore where they spent >75% of their time.

Our results suggest that the combination of high productivity in the vicinity of tidal fronts and complex, submerged topography of the Sahul Shelf provide a productive foraging ground for flatback and other turtle species within the region and may require more targeted protection. Our study is the first to provide an analysis of post-nesting telemetry data on this species and to objectively identify the marine areas of importance and the bio-physical drivers of their movement.

**Acknowledgements**: We would like to thank Woodside Energy for the use of the telemetry data.

# Artificial Light on Water Attracts Turtle Hatchlings During their Offshore Migration

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Investigation of in-water movement of turtle hatchlings has been hampered by the small size of hatchlings relative to the size of available tracking technologies. We used new miniature acoustic transmitters to track turtle hatchlings in order to measure the influence of artificial light. The tracking system consisted of an array of 36 acoustic receivers deployed near the benthos in the surf zone at Ningaloo, Western Australia to detect signals from coded acoustic transmitters attached to 40 green turtle hatchlings released into the array. Ten hatchlings were released into the array in each of two treatments, with artificial light present (on board a boat moored at the edge of the array) and under ambient conditions over two nights. The receiver array was used to obtain high resolution x-y positions of the turtles moving through the array. Positions were calculated if a transmission from an animal transmitter was simultaneously detected on at least three time-synchronised receivers. These detections were converted into positions using differences in arrival times of the same signal at different receivers.

In both ambient light treatments the hatchlings fanned out in in a similar manner, in a largely northerly direction from the release sight and spent 19 ± 5 and 12 ± 3 minutes respectively in the array. In the artificial light treatments, 80% and 100% of turtles travelled to the position of the light (north-west of the release site on night one and north-east of the release site on night two) and remained in the array for significantly longer (22 ± 2 and 18 ± 9 minutes respectively). A current meter deployed in the array showed that the currents were quite low at around 9cm $s^{-1}$ over both nights but the direction was towards the north-east on the first night and towards the north-west on the second night. The turtles did not appear to move with the currents in any of the experimental releases.

We also measured the surfacing rate of turtles with and without dummy transmitters as a proxy of effort, as a test of the effect of the tag on the hatchling's swimming behaviour. We did not discern any difference, with both groups having similar surfacing rates (8.5 ± 4.2 and 8.5 ± 6.2 seconds respectively). We have shown empirically that wild turtle hatchlings are attracted to light and that light causes hatchlings to linger longer in the nearshore zone, thereby increasing predation risk. Our results have important implications for the management of artificial lights on water in the vicinity and adjacent to turtle nesting beaches.

# Mitigation Measures for Minimising Turtle Interactions with Commercial Fishing Gears in Western Australia

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Worldwide, one of the primary threats to sea turtles is fishing activities, with numerous sea turtles incidentally captured by commercial fishing gear each year. Within Western Australia, all sea turtles are protected under State and Commonwealth legislation, and fisheries operate under a legislated requirement to minimise interactions with these species and to report any incidents that do occur.

There are currently 46 commercial fisheries in Western Australia, of which 18 have reported at least one sea turtle interaction since 2006. The majority of these interactions have been reported in prawn, scallop and finfish trawl fisheries and demersal longline and gillnet fisheries. Mitigation measures in place for minimising endangered, threatened and protected (ETP) species (e.g. marine mammals, sea turtles, sea snakes, sawfish and syngnathids) interactions in these fisheries include overall effort controls, spatial and temporal closures and gear controls. The development of these measures are the result of ongoing collaboration between management, research and fishing industry, and many of these fisheries have been proactive in seeking new and innovative ways to reduce sea turtle and other ETP species interactions over the past few decades.

Turtle mitigation in trawl fisheries has been successfully addressed through the use of bycatch reduction devices (BRDs), particularly grids (also referred to as turtle exclusion devices or TEDs). BRDs have been mandatory in all prawn and scallop trawl nets since 2002/03. The BRD implementation program in these fisheries included two years of dedicated research into the performance of BRDs in reducing the incidental catch of large animals and smaller fish and invertebrate species (Broadhurst et al. 2002; Kangas and Thompson 2004). This led to legislating minimum BRD standards, while still allowing innovation and experimentation by industry. Key benefits of TED implementation in these fisheries has been a 95 – 100 % reduction in the capture of larger sharks, rays and turtles (Kangas and Thomson 2004).

The Pilbara Fish Trawl (Interim) Managed Fishery also has a long history of developing and adopting mitigation measures that have resulted in very low capture rates of ETP species, including the use of BRDs since 2006. Recently, research in this fishery has focused on improving understanding of subsurface interactions and exclusion gear effectiveness. In order to examine these issues, all trawl vessels in the fishery were fitted with dual-lens above water and subsurface within-net camera systems over a six month period in 2012. ETP megafauna captured in trawl nets over this period represented a very small proportion of the overall megafauna observed in nets during trawling. Within-net observations of the efficiency of exclusion gear determined that all three configurations successfully facilitated escapement of megafauna, with approximately two-thirds of all megafauna that entered trawl nets exiting through an escape hatch. All grey nurse sharks and sea turtles were observed to exit the net through the escape hatch, with very high rates of escapement also observed for sea snakes (Wakefield et al. 2014).

The development and refinement of ETP species mitigation strategies in Western Australian fisheries is an ongoing process. Future work to further reduce fishery impacts will include continued trialling of BRDs in collaboration with industry, collation and validation of information from fishers regarding interaction rates and networking with other scientists around Australia and overseas to share research experiences.

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# The Kimberley Marine Turtle Project under the Western Australian Marine Sciences Institution (WAMSI)

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Western Australia's marine turtle projects encompass nesting habitats, foraging grounds, or migratory routes for six sea turtle species, with flatback turtles, green turtles, loggerhead turtles, and hawksbill turtles the predominant nesting species. WA's history includes monitoring at more than 30 rookeries (with selected datasets spanning 1987-2014), four foraging grounds, and six turtle care and rehabilitation facilities. The research and monitoring stakeholders include State wildlife and fisheries agencies, Indigenous rangers, environmental consultants to industry, academic institutions, and community conservation groups. The collaborations generate information and data essential to successful marine turtle co-management.

A current focus of the Western Australian Marine Science Institution (WAMSI) is the Kimberley Marine Research Program Node. The WAMSI collaboration between 15 agencies provides an understanding of key ecosystem processes in the region and their response to a range of potential human impacts, including climate change. Projects are conducted across the Kimberley with emphasis on the existing (Camden Sound and Eighty Mile Beach) and proposed (Roebuck Bay and North Kimberley) marine parks (Figure 1). The breadth of all 25 WAMSI research projects extends beyond the narrow scope of this talk, but is detailed online http://www.wamsi.org.au/programs.

We outline the WAMSI Marine Turtle Project and explain its structure and partners that seek to acquire new data or information essential to management of marine turtles in the remote Kimberley coasts of Australia. The Kimberley coastline of 2,633 islands and 1,375 mainland beaches has 91% of its available rookery habitats accessible only by foot, boat, or helicopter. Consequently, all field surveys present a significant challenge whether in logistic, temporal, or financial terms. Partners in WAMSI 1.2.2 Kimberley Turtle Project include the Western Australia Department of Parks and Wildlife (Parks and Wildlife), The University of Western Australia (UWA), CSIRO, Griffith University, and Pendoley Environmental.

The WAMSI Marine Turtle Project adopts a rookery-based approach with its main focus to determine the spatial and temporal distribution of nesting by species. The project will also define appropriate longer-term monitoring strategies to continue beyond the life of this project. With many Saltwater Country Plans, Healthy Country Plans and Indigenous Protected Areas completed or in progress, the opportunity also exists to develop and strengthen co-management arrangements between indigenous rangers groups and Parks and Wildlife for new marine parks of the Kimberley coast.

With major knowledge gaps for this part of Australia the major drivers for this project were to:

- determine the significance of turtles to the proposed marine parks
- determine condition, pressure response indicators for marine turtles which can be used for development time-series data for monitoring
- determine the spatial and temporal nesting abundance which is needed for development assessments both in State and Commonwealth waters
- determine the management units (based on genetics) to enable strategic management
- determine basic biological parameters required to monitor trends
- What species visit Kimberley beaches?
- When/where are they nesting?

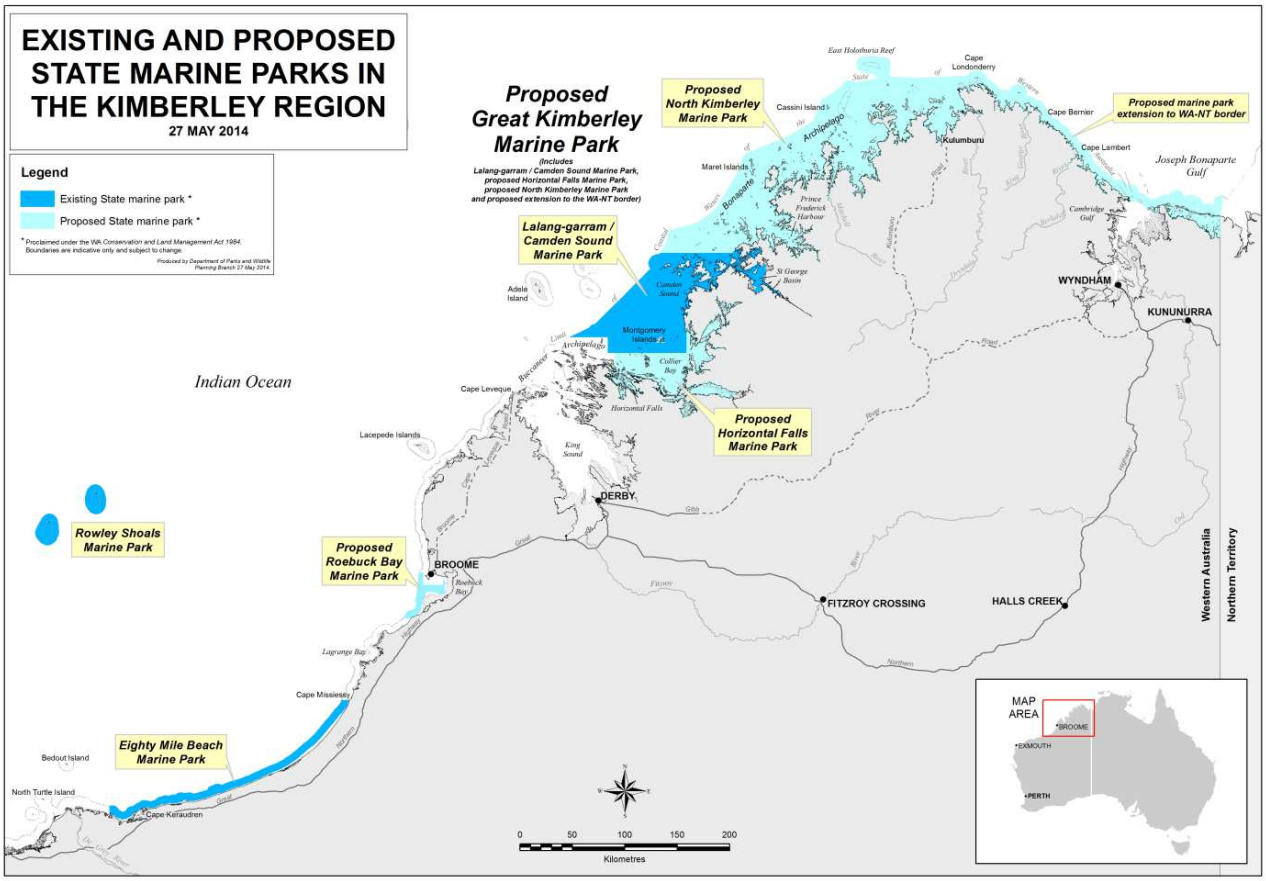


Figure 1. The spatial extent of existing and proposed marine parks across the Kimberley Region.

- How are these turtles related to other groups?
- What are impacts of climate change?
- How do traditional and scientific knowledge complement each other?

### Species inventory, distribution and abundance

Currently there is no comprehensive understanding of the spatial and temporal distribution of marine turtles nesting by species across the Kimberley. An inventory of nesting will be conducted using a combination of aerial surveys, on ground surveys and remote cameras on nesting beaches. The coastline will be categorised using satellite or aerial imagery and stratified for aerial survey.

Existing information on flatback turtles indicates that winter nesting occurs in the east Kimberley and summer nesting occurs in the west Kimberley.

Aerial surveys using a plane with GPS wing mounted camera with be conducted in mid-summer and mid-winter and will photograph beaches with overlapping geo-tagged images with enough detail to identify turtle tracks to species. The images will be analysed later and archived. A combination of aerial and ground surveys will fill in gaps in nesting seasonality and confirm nesting species.

### Genetic identification of management units/population stocks

Few genetic samples from green, flatback and hawksbill turtles in the Kimberley mean that they have not been assigned genetic stocks. The flatback samples collected during this project will augment a range-wide stock structure analysis already conducted with new samples from the central Kimberley to help define the summer and winter nesting populations. The North West Shelf green turtle stock will be revisited to determine if there is substructure within the stock between the North West Cape rookeries and those in the Kimberley. The outcomes will better define the management units found in the Kimberley and their relationship to stocks across the Northern Australia coast that feature in State or Commonwealth recovery plans.

## Impacts of climate change

In marine turtles, hatchling sex is determined by the temperature experienced during incubation (temperature dependent sex determination or TSD). Females are produced at higher nest temperatures and males are produced at lower nest temperatures. Climate change will increase sand temperatures at turtle rookeries and could potentially increase the proportion of female biased nests and so alter primary sex ratios.

A primary aim of this project is to precisely determine the thermo-sensitive period (the TSP – the period of development when gonads differentiate into either testes or ovaries) for the Western Australian genetic stocks of flatback and green turtles. The quantification of this key aspect of the turtle's physiology will help refine models of how hatchling sex ratios of this vulnerable species vary temporally and spatially, and under the influence of a warmer climate.

## Sharing traditional and scientific knowledge

Sea turtles are an important part of culture for Indigenous Australians in the Kimberley and this project recognises that Indigenous Knowledge and local knowledge forms an integral part of documenting knowledge of sea turtles. Traditional owners and rangers will be vital to establish long-term monitoring and management of future Marine Parks across the Kimberley. This will be done in conjunction with Parks and Wildlife both in Broome and Kununurra and with liaison with the Kimberley Land Council (KLC)

Indigenous knowledge and engagement includes training in standard track count methods for long term monitoring, hatching success, and predator documentation. More innovative techniques such as cyber-tracker and remote camera monitoring are also covered in workshops and field training.

## Acknowledgments

Traditional owners and rangers from the KLC, Nyangumarta, KaraJarri, Yawuru, Nyul Nyul, Bardi Jawi, Dambimangarri, Wunambal Gaambera, Balanggarra, and Miriuwung Gajerrong groups. Parks and Wildlife staff and marine parks officers from the Broome and Kununurra offices.

# Life in the Mud: Exploring the Nocturnal Basking Phenomenon of a Marine Megaherbivore in a Coastal Seagrass-Mangrove

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Estimating current and future population trends is critical for providing accurate and effective management for large marine species. Many of these species have complex life histories that span across wide geographic regions, making population trends difficult to accurately assess. The green turtle (*Chelonia mydas*) is one such species, where large stage-specific migrations occur throughout their life cycle. Many current population trend estimations for green turtles are based solely on nesting sites and don't take into account other life stages such as benthic feeding phases. In the current study, we estimated annual survival probabilities and abundances for both juvenile and sub adult/adults in a nocturnal green turtle basking habitat in Hervey Bay, Queensland. We also modelled temporal and spatial trends in encounter probability given a range of environmental, physical and biological factors. Using capture-mark-recapture techniques over an eight year period, 876 individual green turtles were captured and a total of 5180 captures occurred. We used a random effects Cormack-Jolly-Seber modelling approach in the program MARK to estimate survival and recapture probabilities. Annual abundance values were then calculated using the estimated recapture probabilities in a Hortvitz-Thompson type estimator. Factors that may affect green turtle abundance were evaluated using a generalised linear mixed modelling approach. The Cormack-Jolly-Seber model revealed that green turtles basking in Hervey Bay have healthy survival probabilities for both juveniles (0.822 (95% CI: 0.775 – 0.869)) and sub adults/adults (0.961 (95% CI: 0.940 – 0.982)). Annual estimated abundances ranged from 289 to 5448 (mean = 1378) juveniles and 371 to 2646 (mean = 1100) sub adults and adults but were generally fairly stable over the eight year period. These results suggest that turtles basking in Hervey Bay are a steady population with a good probability of survival over time. Generalised linear mixed models showed that green turtle abundance is positively affected by periods of high rainfall. This could be due to benefits of rainfall such as reduced parasites and increased nutrients which could stimulate primary production. The models also showed that juveniles and sub adults/adults use the habitat at different rates depending on the latitude. These results could all have revealed differences in food preferences and habitat use between juveniles and sub adults/adults. Finally, these models showed that turtles prefer to bask in creeks in their natural state in comparison to creeks that have been altered by people. This finding is imperative to the future conservation of the green turtles in Hervey Bay as it has outlined the importance of protecting this habitat from human-induced changes.

# A Review of the Spatial Distribution of Marine Turtle Nesting and Foraging Areas in Western Australia

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The spatial distribution of marine turtle species has been documented in Western Australia since 1984. Over the years, many peer-viewed papers, conference proceedings and consultancy technical reports have contributed to our knowledge of nesting sites and foraging areas within the Northwest Shelf Management Unit (e.g., Prince 1993, 1994, 2001; Waayers 2004, 2010; Pendoley 2005; Limpus 2006; Salinovich 2007; Whiting et al 2008; Koch et al 2008; Biota 2009; Chevron 2009; RPS 2009, 2011; Pendoley Environmental 2010; Waayers et al. 2011; MacFarlane 2011; Waayers & Fitzpatrick 2013; Pendoley et al. 2014; Reinhold & Whiting 2014). However, the information from these documents has not recently been compiled to spatially represent the Northwest Shelf turtle populations in Australia. This paper compiles available information from conservation groups, academic research and industry projects to demarcate the nesting and foraging habitats of all marine turtle species found in Western Australia.

## Nesting Sites

The nesting distribution analysis shows some clear latitudinal delineation between species (Figure 1):

- Loggerhead turtles nesting in the southern latitudes (25.857 – 22.698°S) between Dirk Hartog island and Muiron Islands
- Green turtles in the southern (22.730 – 20.386°S) and northern latitudes (16.873 – 13.960°S) with presence in the northern offshore island (Ashmore, Browse and Scott reefs)
- Flatback turtles covered most of the Western Australia coast (21.689 – 13.963°S), which have been divided into southern (southern Pilbara region), mid (Mundabullanga to Lacepede Islands) and northern (Bonaparte Archipelago) nesting sites. The largest known flatback turtle nesting site in Western Australia is located at Cape Domett in the Joseph Bonaparte Gulf
- Hawksbill turtles mostly concentrated in the southern Pilbara region (21.847 – 20.469°S) with some nesting recorded in the northern Kimberley region
- Olive ridley turtles have been recorded sporadically in the mid Kimberley region.

While there is some overlap between these areas, there appears to be little sharing of nesting beaches. The spatial assessment showed longitudinal nesting demarcation with green and hawksbill turtles generally nesting on the western side of islands and flatback turtles mostly on the landward side of islands and closer to the mainland.

## Foraging Areas

Key foraging areas were identified using seaturtle.org data (BHP Billiton, CVA, WWF Indonesia and Ningaloo Turtle Program), technical reports (Inpex Ichthys, Woodside Browse, and Chevron Wheatstone) and scientific papers (e.g. Whiting et. al. 2007). For the purpose of this investigation, a foraging area was established if the turtle ceased post-nesting migrating and remained within a 50km radius for >30 days.

In Western Australia, the majority of satellite tags have been deployed on flatback turtles. We analysed 90 flatback tracks that reached their foraging area and outlined the extent of their home range

based on ARGOS locations. The results indicate that there are several prevalent foraging areas in Western Australia with the northern Kimberley region supporting flatback turtles and other turtle species. A total of 18 tracks (20%) remained within the northern Kimberley region with relatively vast movements between Penguin Deeps, Londonderry Deeps and the Sahul Shelf (Figure 2). This area has recently been identified as an important foraging area for flatback turtles (Waayers & Fitzpatrick 2013; Pendoley et al. 2014; Thums et al in review). Other key flatback turtle foraging areas in Western Australia with a narrower distribution included: West Dampier Peninsula (13), Cape Missiessy (9), the Kimberley Shelf (9), South Pilbara (8),Turtle Island/Port Hedland (5), north of Cape Leveque (7) and Van Dieman Rise in the Northern Territory (3) (Figure 2). There appears to be a transfer of flatback turtles between Western Australia and the Torres Strait (TS)/Gulf of Carpentaria (GoC). A turtle released at Cemetery Beach migrated 2,900km to the eastern GoC, while a turtle from Warul Kawa, TS travelled 1,700km to Londonderry Deeps in Western Australia.

The green turtle foraging areas appears to be wide spread across Western Australia, Northern Territory and Queensland (Figure 2). Of the 33 tracks analysed, the majority of green turtles migrated across northern Australia to nearshore waters of the Bonaparte Archipelago (5), waters surrounding the Tiwi Islands (5), Coburg Peninsula (4), western GoC (3) and Thursday Island (2). Eight turtles migrated south to foraging areas at Roebuck Bay (3), Eighty Mile Beach (4) and Turtle Island. Two turtles released from Sakamade in East Java migrated approximately 1,500 km south to the southern Kimberley area. The furthest migration was approximately 2,800 km from Scott Reef to Princess Charlotte Bay in Queensland.

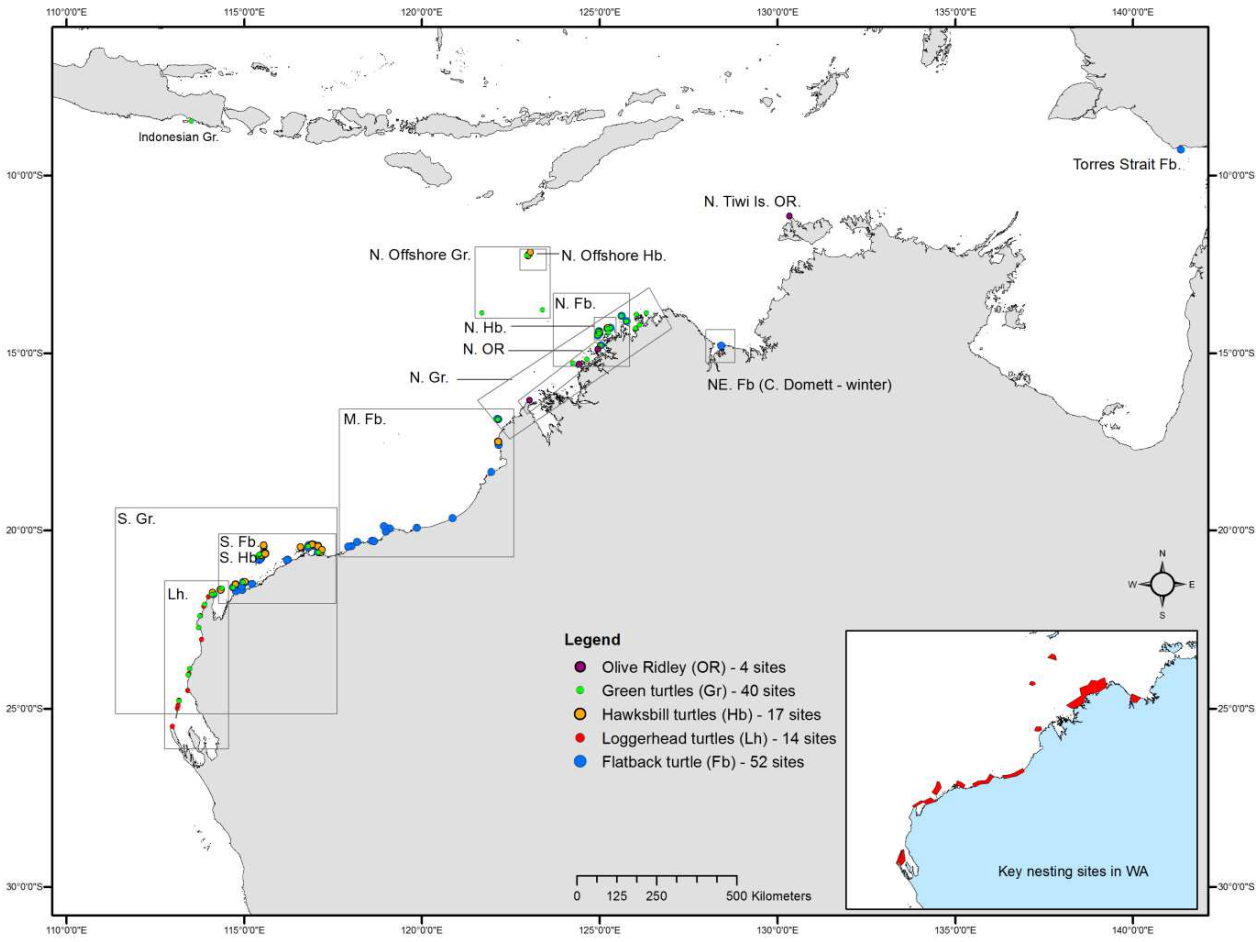


**Figure 1.** Nesting sites in Western Australia and sites where turtles have migrated to Western Australian waters. This information was based on available data from EIA technical reports, NGO projects and government reports.

Nine loggerhead turtle tracks were analysed from a nesting site at Yardie Creek on the Northwest Cape (Figure 2). The results indicate that most of the turtles migrated north to the similar foraging areas occupied by flatback turtles, including Cape Missiessy, Eighty Mile Beach, West Dampier Peninsula, Sahul Shelf, Van Dieman Rise and Cook Reef off Thursday Island. Two turtles migrated south and both resided in the Shark Bay area.

Of the four olive ridley turtles released from Cape Van Dieman (north west of the Tiwi Islands), three migrated to the Joseph Bonaparte Gulf, while one turtle migrated to the Sahul Shelf – an area that also supports flatback and loggerhead turtles (Figure 2).

No hawksbill tracks are currently available for publication.

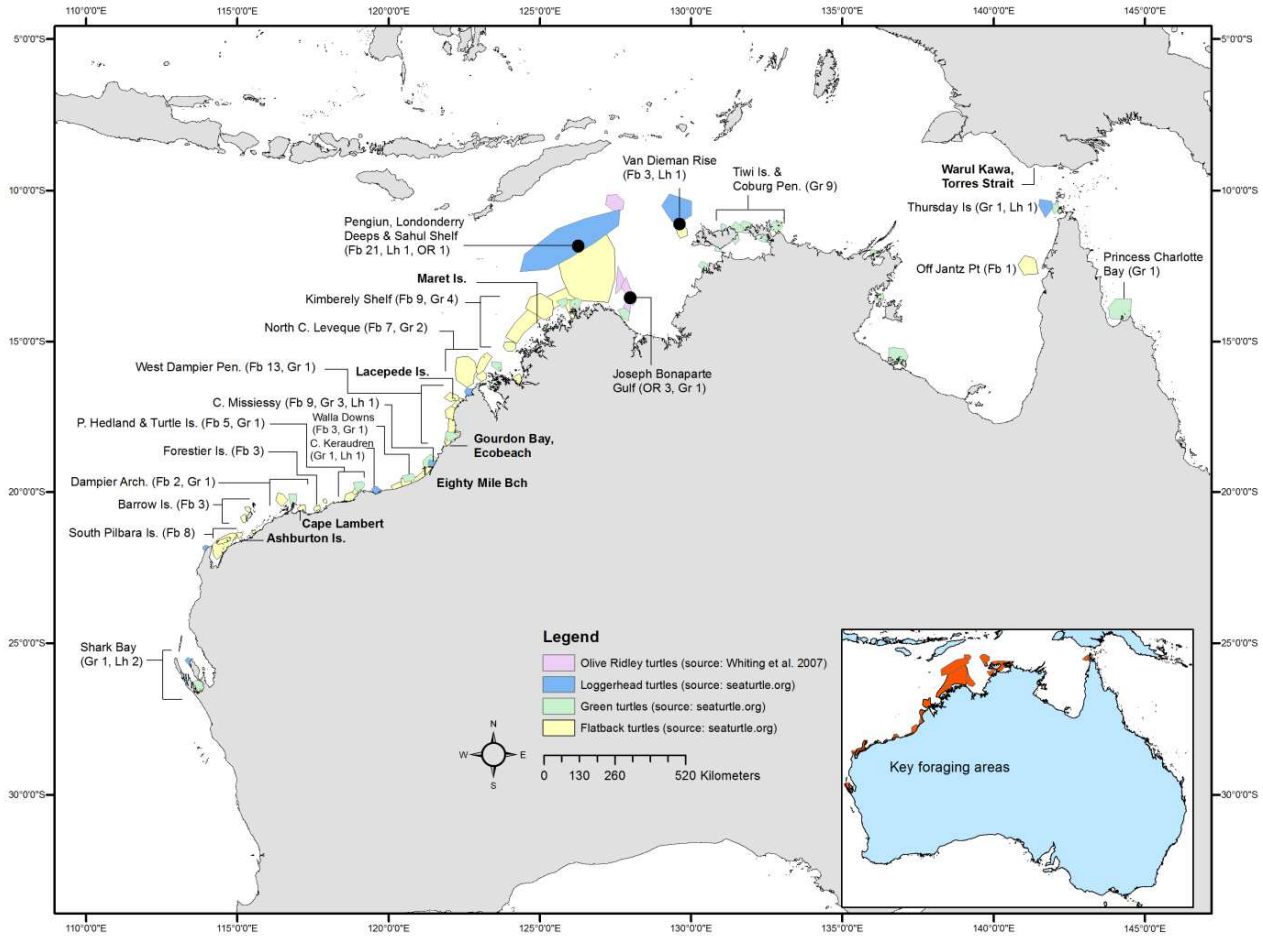


**Figure 2.** Foraging areas of marine turtles nesting in Western Australia. The coloured polygons represent the extent of the foraging area for each species.

## Conclusions

The northern Kimberley region appears to be important foraging habitat for flatback, loggerhead and olive ridley turtles nesting at Western Australian beaches. These data show there are multilateral movements across northern Australia, requiring a collaborative management strategy for protecting these areas from nearshore and offshore development. This dataset provides the baseline for investigating future developments and research in turtle ecological studies. By over-laying other parameters, such as proposed and existing developments, vessel traffic, bathymetry, habitats maps and protected area boundaries, we can start to build a broader understanding of cumulative impacts on turtles.

While this paper provides the first compilation of satellite tracks of turtles in Western Australia, further research in mating areas, juvenile turtle habitats, flipper tag recapture data and aerial surveys is needed to comprehensively map the movements of turtles.

**Acknowledgments:** We would like to thank the following companies and organisations for providing access to their seaturtle.org data as included in Figure 2: Woodside Energy, Inpex Corporation, Chevron Australia, Rio Tinto, BHP Billiton, Conservation Volunteers Australia, Ningaloo Turtle Program, James Cook University and WWF Indonesia.

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# Distinguishing Between Tracks and Clutches for Nesting Turtles: How Survey Techniques and Uncertainty Impact Abundance Estimates and Trend Detection

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Abundance surveys of nesting sea turtles often use counts of clutches or tracks to represent the number of turtles coming ashore. In lieu of substantial long-term capture-mark-recapture studies, a count survey is often used to present an estimate of population size which can then be used to compare between populations or look at trends within the one population. A major source of uncertainty (including error in track species identification and nesting success estimates) in nesting sea turtle abundance surveys can arise when tracks are counted instead of clutches or turtles. How much inherent uncertainty there is will have an impact on the confidence of abundance estimates and the ability to detect real trends in populations. We investigated differences in the proportion of tracks resulting in successful egg deposition, arising from different methods of detection – comparing indirect detection using day surveys looking at track characteristics and direct detection using night surveys watching for the presence of eggs. Uncertainty from sample sizes were investigated using simulation modelling based on binomial distributions, nesting success data published in the literature and case studies from loggerhead turtles nesting at Ningaloo Marine Park and flatback turtles nesting at Cape Domett. Impacts from sample size and spatial and temporal differences were investigated, and their impact on trend detection and abundance estimates were explained in relation to the different nesting behaviours of the different species of sea turtles. At Ningaloo Marine Park, nesting success for loggerhead turtles using the indirect and direct detection methods was within expected limits (8.2%) based on binomial sampling (n= 74). In contrast, there was a much larger than expected difference in nesting success between indirect and direct detection methods for flatback turtles at Cape Domett (17.9% difference, n= 44) with the direct detection method producing a higher estimate. Further research is needed to ascertain why differences in estimates between methods occurred at Cape Domett and not at Ningaloo Reef. This may be attributed to spatial or temporal variability between the samples, species or density specific differences, or error in identification methods.

# Planning for the Future: Constraints and Opportunities for Long-Term Monitoring of Marine Turtles in Western Australia

***Scott Whiting and Tony Tucker***

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The long-term monitoring of biological resources or assets is key to any adaptive management and conservation program. This is particularly true for long-lived species or species and habitats where lags may occur between the time of any impact and changes detected to a responding parameter. For the purposes of this paper, monitoring refers to the collection of time series data on key parameters as opposed to research which focuses on specific questions and is generally short in time scale. Indicators are usually selected key parameters that alert the manager of important changes that may be occurring to a species or habitat, which are considered the assets in a management context.

Funding for biological monitoring is usually allocated over short to mid-term periods with additional monitoring occurring irregularly or opportunistically during other targeted research activities. For the rare cases of long term monitoring plans, fluctuating funding availability can modify the activities and methodology over the course of the monitoring period.

The monitoring of marine turtles in Western Australia over the past 20 years has been highly influenced by various factors but dominated by funding cycles. The challenges related to long term monitoring (such as consistency in data collection and coverage across species, locations and life stages) can be improved by a more coordinated effort across the diversity of stakeholder groups that conduct monitoring.

Starting around 2000 several main stakeholder groups have emerged outside the Department of Parks and Wildlife who conduct marine turtle monitoring in Western Australia. They each have different drivers, funding sources, goals and capacities. The monitoring programs of these stakeholder groups were also influenced by the binding and non-binding requirements placed upon them by legislation and regulators through WA Department of Parks and Wildlife, Department of Fisheries, Marine Parks and Reserves Authority (MPRA), Environmental Protection Agency, Commonwealth Department of the Environment and the Commonwealth National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

The Department of Fisheries have specific needs in relation to turtle monitoring that are mostly centred around bycatch from trawl fisheries. Since a national mandate to install bycatch exclusion devices in 2003, the bycatch of turtles has markedly diminished and there are long-term programs in place that collect these data (Travaille et al. 2015)

The Department of Parks and Wildlife has a legislative responsibility for the conservation of wildlife under the *Wildlife Conservation Act 1950* and for the protection of key assets within protected areas under the CALM Act 1984 administered through the MPRA. Generally, core funding for marine monitoring within Parks and Wildlife is low. In addition to this core function, Parks and Wildlife also receive funds to deliver Environmental Offsets related to industry development projects.

Industries, including oil and gas, mining and urban expansion projects, often have their project approvals based upon conditions that require them to conduct research and monitoring around key assets that may be impacted during the life of the development. The monitoring can be of short or long time scales. Industry may also negotiate to self-deliver any of the environmental offsets required by these conditions. The largest marine fauna related offset from recent years is the Gorgon Gas North West Shelf Flatback Turtle Conservation Program (NWSFTCP) that is specific to improving conservation status of the region's flatback turtle management unit. Technically this is termed an Additional Undertaking, but operates much the same as other environmental offsets.

The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) requires the oil and gas industry to collect marine biological information that is relevant in the event of an oil spill. This information needs to be sufficient to guide mitigation activities during an oil spill event

(Field 2015) and provide enough baseline information to measure impact and guide rehabilitation after an oil spill event.

Indigenous ranger programs have developed across northern Australia since the early 1990s. Coastal ranger groups have cultural obligations to look after turtles and many have begun monitoring nesting turtles. The capacity of these groups is expanding but long-term funding is uncertain. Non-government or community-based conservation groups have periodically started marine turtle monitoring in Western Australia. These have been driven by internal organisation goals rather than any external requirement. In many cases they have initiated good projects that have then been continued on by other organisations in the longer term. The Ningaloo Turtle Program is a good example of a project that begun as a three way partnership between Cape Conservation, WWF Australia and the Department of Parks and Wildlife (then CALM) (Coote and Lalor 2013). The Care for Hedland Program (Howlett 2015) is a great example of a longer term monitoring program, but there are few community NGO organisations that have the capacity to conduct decadal monitoring projects.

Private stakeholders provide useful information about marine turtles, often filling knowledge gaps and starting monitoring programs (Hattingh et al. 2013). Often these programs are related to refinement of their own business models to include conservation objectives. However, few have the capacity for decadal monitoring.

Universities generally do not run long-term monitoring projects and often do not have the required databases to span across projects and the tenure of individual researchers. University projects are often research based over short time scales and are mostly driven by academic outputs, measured in peer reviewed papers. Monitoring projects generally do not have high academic output compared to innovative and short term research projects.

**Way forward**

To manage long-lived, wide ranging species such as marine turtles, a coordinated effort among stakeholder groups is the most efficient and effective means of providing consistent, continuous, accessible data with adequate spatial and temporal coverage. A cooperative effort among stakeholder groups can deliver effective and efficient monitoring statewide which cannot be achieved by any single stakeholder group alone.

The Department of Parks and Wildlife will coordinate long-term monitoring of marine turtles across Western Australia and will finalise a draft statewide plan that closely fits the framework of the Commonwealth recovery plan.

Parks and Wildlife will continue to train volunteers and field staff, become a repository and archive of tagging and monitoring data that currently are isolated within Parks and Wildlife districts, synthesise grey literature of environmental monitoring reports to industry, and strive to align and standardise monitoring data collection across organisations.

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**Table 1.** Biological monitoring of marine turtles is delivered by different stakeholder groups in Western Australia. Summaries within stakeholder groups have been made that may not reflect all organisations within the group.

| Stakeholder | Collecting monitoring data | Drivers for monitoring | Time scale of munding | Size of funding | Spatial scale of operation | Operational capacity (staffing logistics) | Data accessibility (management) |
|---|---|---|---|---|---|---|---|
| Department of Parks and Wildlife | Yes | CALM and Wildlife Conservation Acts | Long | Small | Large | Good | Good |
| | Yes | Administering of Environmental Offsets | Long, Mixed | Large | Mixed | Good | Good |
| Industry – compliance monitoring | Yes | Approvals and Compliance | Mixed | Large | Small | Good | Poor |
| | Sometimes | Administering of Environmental Offsets | Mixed | Large | Mostly small | Good | Poor |
| | Baseline only | NOPSEMA conditions | Mostly short | Mixed | Mixed | Good | Poor |
| Indigenous ranger groups | Yes | Cultural obligations to look after country, local employment | Mixed | Mixed | Mixed | Good | Mixed |
| Non-government agencies | Sometimes | Various conservation and business objectives | Short | Small | Small | Mixed | Mixed |
| Department of Fisheries | Yes | Ecosystem based management and bycatch monitoring | Long | Small | Large | Small | Good |
| Private (eg Gnaraloo Station | Yes | Various conservation and business objectives | Short or uncertain | Small | Small | Small | Mixed |
| Universities | No | No driver | Short | Mixed | Small | Small | Mixed |

# A Novel Method for Integrating Light and Marine Turtle Hatchling Orientation Data

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A critical aspect of environmental management in the vicinity of marine turtle rookeries is the measurement, monitoring and management of artificial light and its impact on marine turtle hatchings. Coastal developments frequently cause conflicting pressures on night time lighting conditions where there is a perception that bright lighting of coastal industrial facilities is needed for Health and Safety purposes while nesting female turtles and emerging hatchlings engaging in sea finding require dark skies. Environmental Practitioners with responsibilities for the protection of marine turtles are required to incorporate a range of biological, physical and social data into the monitoring and management of this interaction between human and marine turtle needs. Complications around precisely and accurately measuring light, in a biologically meaningful way, together with the inherent variability in biological data, have impeded the development of a tool that can be used to quickly and easily collect, process, and present data in a way that is easily interpreted and understood by both scientific and non-scientific personnel. This presentation outlines a novel tool we have developed to integrate light and biological data. Results will be presented to demonstrate the collection, processing and interpretation of light data collected using CCD technology, together with hatchling sea finding (fan data). The result is a graph that is intuitive, easily read and interpreted, and one that can be easily updated with new data.

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# Investigating the Impact of Ghost Nets in Northern Australia – an Analysis of Catch Rates and a First Estimate of the Number of Turtles Impacted

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Globally, 6.4 million tons of fishing gear are lost in the oceans annually. This gear (i.e., ghost nets), whether accidently lost, abandoned, or deliberately discarded, threatens marine wildlife as it drifts with prevailing currents and continues to entangle marine organisms indiscriminately. Northern Australia has some of the highest densities of ghost nets in the world, with up to 3 tons washing ashore per kilometre of shoreline annually. This region supports globally significant populations of internationally threatened marine fauna, including five of the seven extant marine turtles. Working together with indigenous rangers from the region and the Ghostnets Australia program, we examined the threat ghost nets pose to marine turtles and assessed whether nets associated with particular fisheries are linked with turtle entanglement by analysing the capture rates of turtles and potential source fisheries from nearly 9,000 nets found on Australia's northern coast. We were able to identify net characteristics that led to particularly high catch rates, and classify them into types of fishing gear using statistically robust approaches. Based on these catch rates we made a preliminary estimate of the number of turtles that would be expected to be caught by these nets, which is in the range of 5,000 to 15,000. This is an important and ongoing trans-boundary threat to biodiversity in the region that requires attention from the countries surrounding the Arafura and Timor Seas.

# First Results of Population Demographics from Citizen Science Collected Photo-Identified Green and Loggerhead Sea Turtles

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An understanding of sea turtle population demography is crucial for making effective conservation and management decisions, however this often requires resource intensive field sampling programs to collate such information. Where resources and baseline knowledge are low, citizen science fuelled monitoring programs are proving to fulfil this deficiency. Here we assess the possibility for citizen science photos to help identify green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles. Photos of left and right facial scute profiles and dorsal view of the carapace of sea turtles taken by recreational divers were solicited. These photos were used to assess basic demographic parameters as an alternative to traditional capture-mark-recapture program. Records of 214 green and loggerhead turtles from 2010 to 2014 were assessed. Residency models for each species were generated using SOCPROG 2.5. Residency behaviour was variable between green and loggerhead turtles. Green turtles resided in the study area for long periods of time, whereas loggerhead turtles were transient. These results have significant conservation implications at the study site given the active and widespread nature of poaching in Mozambique. A practical evaluation of the pros and cons of this methodology will be presented. Finally we discuss the conservation implications of our findings in light of applicability in Australia.

**Acknowledgements**:

Special thanks to the project coordinators and volunteers of the All Out Africa Marine Conservation Project and Marine Megafauna Association who collected photo-ID data. This project was supported by Peri Peri Divers, Idea Wild and Rufford Small Grants for Nature Conservation. For more information see www.mozturtles.com

# Eighty Mile Beach Turtle Monitoring Program: Past, Present and Future

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Eighty Mile Beach is a 220km uninterrupted stretch of remote coast located in the Kimberley Region of Western Australia. Eighty Mile Beach was proclaimed a Marine Park in 2013, jointly managed by the Department of Parks and Wildlife together with the Traditional Owners to afford a higher level of protection to the key ecological, cultural and social values of the area. Aside from being an important flatback turtle rookery with adjacent foraging grounds, Eighty Mile Beach is also a RAMSAR listed wetland due to the vast intertidal mudflats (up to 4km in width) which are of international significance for migratory shorebirds.

The Eighty Mile Beach flatback nesting population is part of the North West Shelf Summer Breeding Management Unit which extends from Exmouth to Dampier Peninsula around the Broome area.

Since 2005, turtle monitoring has been occurring at various sites along Eighty Mile Beach, albeit inconsistently. The following conditions require consideration prior to delivering a robust and consistent monitoring program at Eighty Mile Beach:

- Scale – 220km length
- Remote location with restricted access e.g. OHS risks
- Environmental factors e.g. windy, fine sand, marshy areas, large tides
- Undeveloped – good reference beach for comparison with adjacent turtle nesting beaches with large-scale extractive industries
- Marine Park – staff and resources for a long-term monitoring program

The current turtle monitoring program was introduced in 2012 and involves:

- Two survey types at the Eighty Mile Beach Caravan Park Site to investigate nesting success and evidence of predators
  - Once a week surveys for 12 weeks throughout the turtle season
  - Two-week daily survey during peak nesting
- Remote camera surveillance to determine levels of predation
- Excavation of nests to determine hatching and emergence success
- Alternating annually between broad-scale drives and aerial surveys for an indication of the distribution of turtle activity along Eighty Mile Beach
- Opportunistic track counts by Australasian Waders Study Group

This season we will also be conducting additional monitoring at the Anna Plains site on Shared Country to be monitored by Karajarri and Nyangumarta, deploying satellite trackers and moving into electronic collection of data (cybertrackers).

Threats to the Eighty Mile Beach turtle nesting population include both natural and introduced pressures with management options referred to below:

- 4Wdriving on the beach – restricted access at night +/- seasonal closures
- Cyclones
- Erosion – monitor, dune revegetation
- Predators – native and introduced – monitoring program
- Cattle – cattle exclusion fence (200km long)

Turtle monitoring is conducted in collaboration with two of the Native Title Holders of the Eighty Mile Beach area – Nyangumarta and Karajarri. It provides opportunities for Traditional Owners (TOs) to work on country, employment, training and capacity building. We also gain valuable traditional ecological knowledge from the TOs.

The program is jointly funded by the Department of Parks and Wildlife as well as the BHP Billiton Iron Ore Eighty Mile Beach and Walyarta Conservation Program - an investment made under the BHP Billiton Iron Ore Community Development Program. The program funds are directed towards projects that meet the long term objectives for conservation in the area and in this case funding facilitated aerial surveys, implementation of a second monitoring site, deployment of satellite trackers, predator surveillance with the use of remote cameras and Traditional Owner Engagement.

# Indigenous Rangers Talking Circle at the Australian Marine Turtle Symposium 2014: Summary of Discussions

***Daniel Oades*** *(compiler - on behalf of those groups in attendance)*

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Presenter - contact: Daniel.oades@klc.org.au

## Introduction

The following issues and discussion points were raised by individuals from Ranger groups across northern Australia who attended the Australian Marine Turtle Symposium. The discussions were held during meal breaks in the formal symposia agenda. The discussion points listed below do not necessarily represent the views of the Ranger Groups but documents some of the issues raised by individuals during the discussions. The groups in attendance were:

## Ranger Groups

- Crocodile Island Rangers
- li-Anthawirriyara Rangers
- Anindilyakwa Rangers
- Bardi Jawi Rangers
- Dhimurru Rangers
- Gumurr Marthakal Rangers
- Uunguu Rangers
- Dambimangari Rangers
- Lianthawirryara Rangers
- Lama Lama Rangers
- Mapoon Land and Sea Rangers

## Representative Bodies

- Kimberley Land Council
- Torres Strait Regional Authority

## NRM Bodies

Cape York Natural Resource Managementt

## General Discussion Points

The key issues, questions and statements that came from the Indigenous land and sea manager discussion were:

- There was a discussion about not knowing where to send or who to share data with in the different jurisdictions. Who holds this? Is it the States, Territories or Commonwealth?
- There was confusion of what the new Commonwealth Marine Turtle Recovery Plan will bring for Traditional Owners. Would Traditional Owners lose some rights to hunt under the review? Will there be appropriate recognition of Traditional Owner contributions to the management of Sea Turtles?
- The group agreed that more clarification was required of the Commonwealth Government's election commitments which were called the National Turtle and Dugong Recovery Plan.
- There was strong view that the importance of turtles in Indigenous Culture needs to be better emphasised. I.e. communicated through traditional stories and what importance turtles play in everyday lifestyle of Indigenous Australians in particular as a preferred food source of many sea country communities.
- The groups recognised the sensitivities around social media and how powerful this can be to place hunting of turtles in the wrong context. Torres Strait plans also deal with this and provide guidance around what people can and can't take photos of.
- The recognised need to bring out previous and current works that has documented how Indigenous people have contributed to our current knowledge about turtles and how Indigenous groups have been collaborating with western scientists for many decades.
- There is a need to highlight the good work of Torres Strait and other groups have done in developing community based management plans for turtle and dugong which are endorsed through a cultural governance model. Working on determining what is traditional customary practice in a modern context is an important area for communities right now.
- Currently many communities such as Mapoon and Torres Strait have their own rules around take of turtle with some communities on the Great Barrier Reef having to put moratoriums on hunting due to many other anthropogenic factors that occur around them.
- Committed funds are required to help communities work through these issues which are complex and intersected with different legislation. The TUMRA process in the GBR is an example of success that

has been increased through funding discussions.

- The Crocodile Island Rangers discussed they are not an Indigenous Protected Area (IPA) yet but managing country regardless and putting a plan in place. Unfortunately the IPA program is fully subscribed and communities can not apply for new projects. However if a community develops a plan of management for country it should be able declare its own IPA and be accepted as such.
- There was a discussion about needing better communication within our communities about hunting protocols or issues, but who should help drive this? It is usually the land and sea management groups if they have one.
- The was a general discussion on cost of buying food versus hunting cost, not a lot of money or jobs in many communities and the nutritional value as well as economic value makes turtle a much better option.
- There was also a discussion for the need to distribute food to families living away from country, i.e., fish or turtle which made people feel better and those family members feeling obligated to do so.
- There was also a discussion on the need to get people together at events such as this to talk about Indigenous specific issues as there is getting less and less opportunities to share ideas.
- For coastal rangers. There is a great need for an updated ghost net data booklet. The current one is over 12 years old. Most coastal communities started off with this WWF program. How can we go about producing a Universal Top End app for users as a suggestion? This may be a long way off in production.

**Specific Discussion Points**

Aboriginal Prescribed Body Corporates (PBC's) role in this discussion

There was discussion around PBC now being peak decision making bodies for native title interests and topics such as hunting. Members or directors of these body corporates are now saying yes or no to ways things/ practices that are happening on country as well as setting aspirations and priorities. The following is a summary of discussion points:

- no decisions should be made without due process;
- decisions should refer back to the Native Title Act or some agreed process; and
- decisions that guide hunting should be made in collaboration with Traditional Owners, community and departments who have authority.

Value of the Symposium

The following points were discussed about the symposium

- eight minutes to present seemed a bit too short;
- maybe there was a bit too much doubling up of the same topics;
- more Indigenous input encouraged and a number of the groups did not commit to come until they saw there was a reasonable number of Indigenous groups attending. They were convinced the wider turtle management world would want to hear about their work;
- Concurrent talks (i.e., two sets of sessions). So you can choose what interests you and spend more time at those including having discussions and questions.

Research Discussion

There was some discussion around turtle research that it is being conducted in isolation of Traditional Owners in a lot of parts Australia. Collaborative research is more common in some places, with some TO's developing their own research with scientists to see what is a worthwhile project on their country. The Kimberley Science and Conservation Strategy was discussed and how some projects are developing methodologies with TO's. The researchers also have an opportunity to learn from Traditional Owners as well.

Rangers and "Working on Country"

There was also concern about continuity of "Working on Country" rangers who do a lot of the work across the north. People were uncertain about the longevity of this program now that it has been absorbed into Prime Minister and Cabinet. Also they were unsure about the five programs of the Federal "Indigenous Advancement Strategy Guidelines" and what will happen to the program in the next few years despite contractual arrangements with communities in place to deliver environmental services to the nation.

# Day Three - Western Australia

On the Western Australian day short informal workshops and information sessions were held to allow people opportunities to mix and share relevant information and discuss State issues. After an ice breaker session, informal workshop sessions included: discussion of WA issues and also the future of State and National symposia; oil spill response and WA's stranding program, flipper and satellite tagging, turtle rehabilitation, and light impacts.

### Ice Breaker Session

This session was designed to promote interaction among delegates. Chairs were set in rows and during a round of musical chairs delegates had two minutes to meet and greet.

### 1. Workshop to discuss the future of the Turtle Symposia at a State or national level

#### Purpose

To discuss the purpose, values and outcomes of holding an Australian Marine Turtle Symposium and to discuss areas of interest.

#### Outcomes

- General agreement that the Western Australian and Australian Symposia are highly valued and should continue biennially.
- The Western Australian event could incorporate other useful components that include: training, skill sharing, information on legislation and funding opportunities.
- Strong feelings were raised about developing other areas of communication that brought stakeholders together and shared information between meetings. A website was suggested that could include services such as:
  - forums;
  - linkages to other sites (seaturtle.org, ioseaturtle.org, libraries);
  - updates (papers, projects);
  - identify gaps in knowledge;
  - connect ranger groups; and
  - contact lists.
- Delegates broke into groups and developed their own lists of issues. These lists were combined on the white board and individuals placed three votes next to the issues they most aligned with. Of 24 issues, the four to receive the most votes (Figure 1) were:
  - collaboration and meaningful networking;
  - knowledge to action;
  - data collection, data sharing, databases; and
  - Indigenous engagement and management.

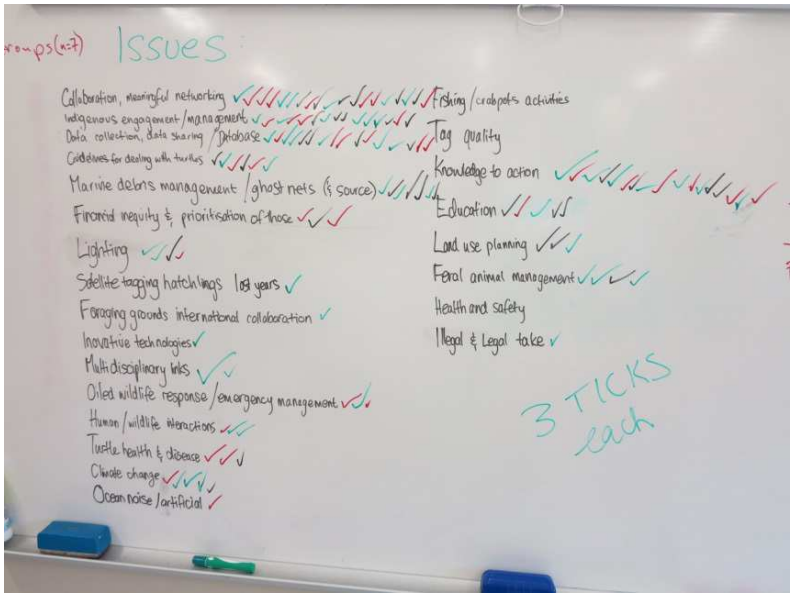


**Figure 1.** A list of issues developed by seven groups and the voting results showing how individuals aligned with these issues.

## 2. Oil Spill Response and WA Stranding Program

*Stuart Field and Scott Whiting (Department of Parks and Wildlife)*

**Purpose**

This was a combined session to discuss the current plans for both Oil Spill Response and marine turtle strandings in Western Australia.

**Outcomes**

- Information sharing

## 3. Flipper and Satellite Tags

*Scott Whiting (Department of Parks and Wildlife) with specialist input from Kevin Lay (Wildlife Computers), Holly Lourie and Guan Oon (CLS), Lou McNutt (Sirtrack), and Ron Duyvestein (Stockbrands Tags)*

**Purpose**

To provide information on current techniques of tagging and marking marine turtles.

**Outcomes**

- Information sharing
- Discuss issues with current flipper tags

## 4. Rehabilitation

*Simone Vitali (Perth Zoo), Cameron Craigie (Department of Parks and Wildlife), Rochelle Ferris (James Cook University)*

**Purpose**

To bring together a diverse groups of practitioners and health care professionals to exchange information.

**Outcomes**

- Information shared through PowerPoint presentations which included legislation and veterinary care
- Discussions and networking

## 5. Light Impacts

*Kellie Pendoley (Penodley Environment Pty Ltd)*

**Purpose**

To get together those individuals with interests and concerns in detecting light and its potential impacts to marine turtles.

**Outcomes**

- Networking and information exchange

# Feedback from delegates

**Table 1**. Summary of responses

| | Topic | Score | 1 | 2 | 3 | 4 | 5 | Number of participant responses |
|---|---|---|---|---|---|---|---|---|
| | | | strongly disagree | disagree | neutral | agree | strongly agree | |
| 1 | The Australian Symposium has provided me with new information and/or skills | | | 2% | 7% | 35% | 56% | 71 |
| 2 | The Australian Symposium has given me a greater understanding of sea turtle research, biology and conservation in Australia | | | | 3% | 39% | 58% | 71 |
| 3 | The Australian Symposium has given me a greater understanding of the pressures on sea turtles in Australia | | | 3% | 14% | 39% | 44% | 69 |
| 4 | The oral presentations were interesting and useful | | | 2% | 3% | 56% | 39% | 71 |
| 5 | The extended tea and lunch breaks, designed to allow time for networking, were useful | | | | 8% | 41% | 51% | 71 |
| 6 | Poster presentations would be an interesting and useful addition to the symposium | | 4% | 5% | 37% | 39% | 15% | 71 |
| 7 | Extra time for questions would be useful at the end of each presentation | | 4% | 15% | 37% | 21% | 23% | 71 |
| 8 | The information provided by the organising committee was clear | | | 1% | 7% | 54% | 38% | 71 |
| 9 | The catering was sufficient in quality and quantity | | | 4% | 9% | 42% | 45% | 71 |
| 10 | The venue was suitable | | | 4% | 13% | 43% | 40% | 71 |
| 11 | If you stayed on site: The accommodation was suitable and you would recommend similar for future symposia | | | 3% | 19% | 40% | 38% | 37 |
| 12 | I would recommend the Australian Symposium to others | | | | 2% | 36% | 62% | 71 |
| 13 | There was enough time to interact and socialise | | | | 7% | 37% | 56% | 71 |
| 14 | For WA delegates who attended the third day: This day was useful for interaction with other delegates or information exchange | | | | 18% | 43% | 39% | 28 |
| 15 | For interstate delegates who attended the third day: This day was useful for either interaction with other delegates or for information exchange | | | 5% | 19% | 38% | 38% | 21 |

The following summary only captures the range of responses to the questions. It is not listed in priority order and does not capture when there were numerous similar responses.

**Table 2**. Short answers

| | | **Summary of answers** |
|---|---|---|
| 1 | What would be the most appropriate format for oral presentations (remain the same at 10 minutes or have a mixture of longer and short presentations? | • This was fairly evenly divided with half agreeing to retaining the short 10-minute talks while the other half suggesting a mixture of short and longer talks. |
| 2 | How with this symposium help you? | • Adds to knowledge and understanding<br>• Networking – exchange information and contacts<br>• Access to up to date research<br>• Feed information back to own organisation<br>• Provides a wider regional context<br>• Helped to identify threats to turtles<br>• Rehabilitation ideas<br>• To practice public presentations<br>• Reinvigorated enthusiasm for turtle work<br>• Better understanding of big picture (national, State news)<br>• Exposure for own program |
| 3 | What improvements would you suggest? | • Presentations broken up by group discussions<br>• Greater rehabilitation workshop component<br>• More stands and displays from conservation organisations<br>• More question time<br>• Some fun structured activities<br>• Lists of groups and research activities<br>• Weekend days to encourage more non-scientist audience<br>• Include some parallel/concurrent sessions<br>• More cultural time<br>• BBQ for dinner – encourage more mingling<br>• Less talks<br>• Posters<br>• More theme based talks<br>• Better dinners<br>• Breakout session for last session<br>• Invited review presentations<br>• Meet and greet before official start<br>• Add an extra day<br>• Divide into management and science focus<br>• More on management implications<br>• More structure for WA day<br>• Need better audio/visual and screen equipment<br>• Tiered seating to allow viewing of screen<br>• Provide a workshop on how to give a presentation<br>• A venue closer to amenities<br>• Provide better discount to students |

| | | |
|---|---|---|
| 4 | What was the highlight of the symposium? | • Presentations ran on a strict timing<br>• Enjoyed the local and community monitoring as it was a good reminder of the social and cultural importance<br>• Hearing from different turtle management groups – scientific, community and Indigenous<br>• Networking<br>• Understanding upcoming issues<br>• Talks on the first day<br>• Meeting other delegates<br>• Understanding of where people work and how to contact them<br>• People getting together<br>• Meeting people<br>• Student projects<br>• Light impacts on turtles<br>• Time allocated for networking was great<br>• Indigenous talks<br>• Better understanding of research and conservation work<br>• Oil spill response<br>• Indigenous perspectives on protecting turtles<br>• Indigenous Land and Sea Managers<br>• Meeting Traditional Owners<br>• The diversity of the people involved in sea turtle conservation<br>• Workshops<br>• Variety of presentations<br>• Resolving tag quality issue<br>• Outcomes of WA day<br>• Chairing a session and helping out<br>• Fun dinners |
| 5 | Do you have any other comments with respect to the symposium or questionnaire? | • Many presenters spoke to their peers and didn't consider the diversity of the audience in the room<br>• A session at the end to draw together major findings would help understanding<br>• Great job, thanks<br>• Fantastic job<br>• Venue was a long way from airport – better shuttles would be good<br>• Showcase Indigenous program, outputs, outcomes<br>• Better discount for students<br>• Discussions around themed topics<br>• Poster of presenters with their photo so they can be found during the meeting |

# Review of event

In general, the feedback from delegates was highly positive. Many comments were centred around the event being highly valuable and worth attending. Many delegates valued the diversity of presentations and the combination of science and management organisations.

The symposium benefitted from sponsorship with attendance costs per day reduced to a minimum. All costs such as venue and equipment hire, accommodation on site and proceedings production were covered by sponsorship. Any further efforts to reduce costs to delegates would require more sponsorship.

The low-key style of the venue and accommodation allowed participation of a wider range of stakeholders and a greater number of delegates than if it was closer to Perth CBD.

Based experience during this event and feedback from delegates, items for the next organisers to consider will be:

- cost structure and sponsorship;
- format of the symposium (ie mix of presentations and workshops, themes);
- oral presentation format and time allocation;
- inclusion of a formal poster session;
- time allocation for networking and socialising;
- social/ice breaker activities; and
- how the values of the event can be used promote and sponsor the event.

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Department of
**Parks and Wildlife**

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