Proceedings of the First

Western Australian Marine Turtle Symposium

28–29th August 2012

Department of
Parks and Wildlife

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Front cover photos

Top left Leatherback turtle. Photo – Dave and Fiona Harvey.

Second row (left) Hawksbill hatchlings. Photo – Marissa Speirs.
(right) Hawksbill turtle. Photo – Heather Barnes.

Third row (left) Loggerhead turtle hatchlings.
(right) Loggerhead turtle. Photos – Linda Reinhold.

Fourth row (left) Flatback turtle hatchling. Photo – Holly Raudino/DPaW.
(right) Female flatback turtle. Photo – Andrea Whiting.

Bottom row (left) Green turtle hatchlings. Photo – Holly Raudino/DPaW.
(right) Green turtle. Photo – Cath Samson/DPaW.

Back cover photo Olive ridley hatchling. Photo – Roy Teale.

Editorial note: The Department of Parks and Wildlife (DPaW) commenced operation on 1 July 2013. All original references to the former Department of Environment and Conservation, Department of Environment and Conservation (DEC), and DEC in this publication can now be read as Department of Parks and Wildlife, Department of Parks and Wildlife (DPaW), or DPaW as appropriate.

Proceedings of the First Western Australian Marine Turtle Symposium 28–29th August 2012

Preface

Western Australia hosts six of the world's seven sea turtle species. Green, hawksbill, flatback and loggerhead turtles nesting populations are of global significance. Limited olive ridley turtle nesting is confined to the Kimberley. Leatherback turtles have not been confirmed nesting in WA, but turtles observed periodically foraging in our waters are part of the poorly known small regional population.

Western Australian people have had a long association with marine turtles. Indigenous Australians have links extending back tens of thousands of years as depicted by rock art and information relayed through songs and stories. Today, many coastal Indigenous communities still retain strong cultural links with turtles which remain important for food and ceremony. William Dampier and other early European explorers exploited turtles for food; and people from parts of what is now Indonesia had strong historical trading links including turtles in northern Western Australia pre-dating European presence. Marine turtles were also regarded as a tradeable commodity from the late 19th century and between the 1950s and early 1970s green turtles were commercially harvested for meat and shell servicing an export trade. Since then turtles have had a high conservation profile and have been key values for many marine parks such as Ningaloo Reef and Shark Bay and have also been a focus for research and monitoring which State government began in the 1980s. Since then turtle research has expanded substantially, with numerous projects led by government, industry, university and community sectors. This expansion of research and conservation activity has created a need to develop a forum such as this symposium to allow people to share knowledge and interact.

The main aims of this symposium were to:

- provide an opportunity for people connected with turtles to meet and interact;
- provide a venue to present research, conservation and management activities related to turtles;
- Encourage future collaborations on turtle research, conservation and management

We are proud to present a compilation of abstracts from the symposium and would like to thank all of the presenters and over 120 participants for making this symposium a success. We have included a summary of feedback from the symposium so we can continue to meet changing needs of stakeholders and hopefully make this a biennial event.

Editorial Committee

Bob Prince, Scott Whiting, Holly Raudino, Anna Vitenbergs, Kellie Pendoley

Foreword

I am delighted and honoured as Chief Scientist of Western Australia to congratulate all concerned with bringing to fruition the "Inaugural Western Australian Symposium for Marine Turtles". My mantra as Chief Scientist is "Do Science, Translate Science and Communicate Science", and I see all these themes encompassed in this timely Symposium.

Marine turtles are creatures that have graced and helped sustain the health of our oceans for at least 110 million years. Their presence in the Indian Ocean, and for brief periods on our shores, delights and intrigues many Western Australians and visitors alike. To help protect these amazing animals in the context of the increasing demands we place on the world's oceans and shorelines, there is a need for long-term and sustained monitoring and soundly based research. These tasks will require a multidisciplinary approach with consistent methodologies as well as collaboration between and within academe, government, industry and the community. The knowledge gained will be of most value if it is shared and owned by all involved, and communicated widely to the community – including to our schools as we engage with the next generation. Such first rate knowledge will be needed to underpin the good management practice, wise policy decision-making and the wide community involvement that are needed to ensure the long-term health of both the environment and our economy.

Marine turtles are wondrous and special: I commend you wholeheartedly for putting them in the spotlight at this Symposium – an event to showcase the good work of the past as well as that being undertaken now, and also to plan for the future. I look forward to the Symposium galvanising future collaborative initiatives that will impact positively for marine turtles and for us all.

Professor Lyn Beazley AO FTSE FACE
Chief Scientist of Western Australia

CONTENTS

Page

Oral Presentations

Diagnosing Sea Turtle Status and Trends: Integrating Demography and Abundance Using Case Studies from WA, PNG and the Caribbean

Milani Chaloupka *

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Reliable estimates of key demographic parameters such as survival (mortality), recruitment and breeding probabilities are essential for modelling the risk of marine turtle exposure to various hazards. These parameters are also essential for diagnosing population status and trends, and so forms the basis of marine turtle conservation planning. While estimates of some parameters such as mortality can be derived from indirect sources such as strandings or satellite telemetry, by far the most useful approach for deriving key demographic parameters is by application of a capture-mark-recapture (CMR) study of either nesting beach turtles or preferably of turtles in foraging habitats where they are resident for most of the year. Most studies focus on nesting populations because adult females are readily accessible on the beach. However, turtles skip annual breeding opportunities due to the energy demands of vitellogenesis and breeding migration. Skipped breeding behaviour or breeding omission results in temporary emigration from the sampled population that can lead to biased estimation of demographic parameters such as survival probabilities. So an open robust design approach for nesting beach CMR studies comprising within-season sampling has been used to address the problem of temporary emigration due to skipped breeding. This approach enables the staggered arrival and departure of breeding turtles to be accounted for in a breeding site CMR study, which helps provide more precise demographic parameters estimates. I discuss the use of this approach to estimate nesting abundance and survival and breeding probabilities for several marine turtle populations in Western Australia (flatbacks, hawksbills), PNG (leatherbacks) and the Caribbean (leatherbacks, greens).

Ningaloo Turtle Program: Progress Summary

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Three species of marine turtle nest within the Ningaloo Coast World Heritage region: Green turtles (*Chelonia mydas*), Loggerhead turtles (*Caretta caretta*) and Hawksbill turtles (*Eretmochelys imbricata*). This includes an important genetic stock of green turtles. As a result of known pressures on turtle populations, the Ningaloo Turtle Program (NTP) was established in 2002 as a collaborative effort between the Department of Environment and Conservation, the Cape Conservation Group Inc. and WWF Australia. The aim of the program is to promote the long-term survival of turtle populations within the Ningaloo Coast World Heritage Area.

The primary goals of the NTP are to:

- Identify key nesting beaches;
- Monitor populations and assess trends at key index sites;
- Identify the level of threat of feral predators on nests;
- Use data collected to implement effective protection of important nesting beaches;
- Generate and maintain community support for the program and for the conservation of turtles and their habitats;
- Educate visitors and the community about turtles.

Each season national and international volunteers and local community members undertake turtle track monitoring on designated sections of beach. Volunteers record data on turtle nesting (per species and by location), predation and disturbance. They also conduct turtle rescues, record tag information and collect mortality data.

The data collected so far have enabled key turtle nesting beaches to be identified, which resulted in consolidation of the NTP in 2010. This allowed the NTP to be managed in a more cost-effective manner with the amount of survey days reduced, while still allowing for future analysis of population trends. To date, 46,833 hours of volunteer time has been contributed to recording 42,175 nests and 100,451 false crawls. The 2011/12 season had the highest level of turtle activity recorded so far. Past analysis indicated increasing population trends for green and hawksbill turtles over a six-year period (no significant trend for loggerhead turtle nesting), however, a larger dataset is required to confirm these trends.

Adaptive management responses that have been implemented as a result of knowledge gained through the NTP include: public education and interactive turtle activities at the Jurabi Turtle Centre, the development of the Turtle Watcher's Code of Conduct, and targeted fox control programs at key turtle rookeries.

As part of NTP's adaptive management approach, new methods to better determine nest predation events will be investigated in the near future.

Ethical Considerations and Operational Guidelines for Turtle Research in Western Australia

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Introduction – Legislative background and requirements

To understand the requirements for use of animals for scientific research in Western Australia, it is first necessary to have an understanding of the legislative requirements that underpin these processes. There are several legislative Acts that relate to conditions under which animals may be used for scientific purposes and these relate to scientific licensing, animal ethics / welfare and the storage and use of drugs.

Scientific Licensing– Animal Welfare Act – Legislation to protect animal welfare is the responsibility of the State and Territory Governments. In Western Australia in 2011 the Department of Agriculture and Food WA (DAFWA) gained responsibility for the administration of the Animal Welfare Act 2002, the Animal Welfare (General) Regulations 2003 and the Animal Welfare (Scientific Purposes) Regulations 2003. 'Animal' as defined by the Animal Welfare Act is all live vertebrates, except humans and fish (and any prescribed invertebrates – currently there are none). Note that there is no distinction made between native and introduced or pest vertebrates – ALL are to be treated humanely! Under this legislation DAFWA issues a 'License to use animals for scientific purposes' to institutions and organisations and monitors their conduct. This license permits the named scientific establishment, its staff and students, to use animals for scientific purposes in accordance with the Australian code of practice for the care and use of animals for scientific purposes 7th Edition 2004 for the period of the license.

Scientific Licensing – Wildlife Conservation Regulations – The Wildlife Conservation Act 1950 and Regulations 1970 are administered by the Department of Environment and Conservation (DEC).

Under this Act 'animal' is defined as any living thing that is not a human being or a plant and includes eggs, larvae and semen. 'Fauna' is defined as any animal indigenous to any State or Territory of the Commonwealth or the terrestrial waters of the Commonwealth and any animal that periodically migrates to and lives in any State or Territory of the Commonwealth or the territorial waters of the Commonwealth and includes in relation to any such animal, the eggs, larvae, semen, carcass, skin, plumage or fur. Under Regulation 17, people who undertake scientific activities using animals are required to have a '*Licence to Take (i.e. capture, collect, disturb, study) Fauna for Scientific Purposes*'. If the scientific purposes are being conducted on land or water that is part of DEC estate, then a license under Regulation 4 to '*Enter DEC Lands or Waters for the Purpose of Undertaking Research*' will also be required. Where proposed activities may have an impact on the values of a World Heritage property or other values regulated by the Commonwealth Environment Protection and Biodiversity Conservation Act 1999, the applicant is encouraged to contact DSEWPaC at the same time as making an application to DEC for research approval to reduce assessment and production delays.

Animal Ethics / Welfare – The Animal Welfare Act 2002 uses the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 7th Edition 2004* as a basis for describing practices and procedures to protect animals used for scientific purposes. The purpose of the Code is to ensure the ethical and humane care and use of animals used for scientific purposes, as defined in the Code. The principles set out are for the guidance of investigators, teachers, institutions, Animal Ethics Committees (AECs) and all people involved in the care and use of animals for scientific purposes. The guiding principles underlying the use of animals are referred to as the 3 R's: *Replacement, Reduction and Refinement* – refer to the Code of Practice for further information www.nhmrc.gov.au/guidelines/publications/ea16

Storage and Use of Drugs – The administration of the Poisons Act 1964 and Poisons Regulations 1965 is the responsibility of the Pharmaceutical Services Branch of the Department of Health. They provide advice, develop policy and administer regulatory control for medicines including drugs of dependency (Schedule 8 medicines), therapeutic goods and poisons. Anyone who is planning to use drugs for sedation, anaesthesia or euthanasia will require a 'Permit to purchase or distribute poisons' from the Chief Pharmacist. The person who will be responsible for purchasing the poisons must be qualified or experienced within the meaning of the Poisons Act Regulations 1965 to handle those poisons requested. The permit holder is responsible for the safe storage of poisons away from foodstuffs and beverages, and out of the reach of children. They must also ensure that all Schedule 4 drugs are only administered by authorised personnel (recognised qualification or endorsement from a registered Veterinarian). Further information may be obtained from the Department of Health website at www.public.health.wa.gov.au/cproot/3611/2/Permit_Application_Form.pdf

Methods

The methods for ensuring compliance with legislation lie with fulfilling the requirements for licensing and documentation. This entails making sure that you have all the correct licenses and have completed all the relevant animal ethics documentation, as listed below.

Licensing Requirements – A vital component of complying with the Animal Welfare Act 2002 is the requirement for scientific establishments to have a scientific use licence from the DAFWA. Information and documentation can be found on the DAFWA website at www.agric.wa.gov.au/PC_95042.html?s=1139806068 or by contacting the Scientific Licensing Officer at scientific.licensing@agric.wa.gov.au Once the licence has been obtained it is a requirement that any staff working in facilities or in the field have a copy of the licence available for public inspection if requested. Failure to show a licence is a breach of the licence conditions and subject to penalties. DEC's corporate licence is available for staff on the intranet or by contacting the AEC Executive Officer. Compliance with the Wildlife Conservation Regulations requires possession of a valid Reg 17 Licence to 'Take Fauna'. Information and documentation can be found on the DEC website at www.dec.wa.gov.au/content/view/864/1992/ or by contacting the Senior Licensing Officer – Fauna at wildlifelicensing@dec.wa.gov.au

Other licences that may also be required are as follows:

Reg 15: Licence to take fauna for educational or public purposes (e.g. fauna relocation)

Reg 16: Licence to keep fauna for education or public purposes (e.g. display)

In the case of an applicant who has collected material under a Reg 17 Licence and who wishes to send this material out of Western Australia to other states, then application for a Reg 18 export licence must be made prior to transport. Please note that import licences may need to be gained from the relevant 'receiving' state or territory government as well.

Animal Ethics Documentation – Animal ethics documentation can be divided into two categories; 1) paperwork associated with project approvals, i.e. applications, amendments and renewals, and 2) reporting documentation, i.e. annual reports, unexpected animal death / emergency euthanasia.

While the overarching format of the operations of an AEC are determined by the Code of Practice, each AEC will conduct its business in the format that works best for the scientific institution involved, so there will be minor differences in the operation of each AEC.

All AEC documentation and explanations of how to complete each type should be available on your institutional website or intranet. If not, please contact your friendly AEC Executive Officer, who will be only too glad to send it to you and clarify any questions you may have.

Results

The results of working with the legislative requirements and the AEC process to ensure best-practice operations and ensure that ethical considerations have been fully accounted for should ensure that projects are approved with the minimum amount of effort and time. By working with the AEC Executive Officer the applicant should be able to ensure that all necessary information has been provided and all staff have the necessary qualifications and experience to undertake the proposed project before the application even goes to the AEC. This should then ensure that the AEC has all the necessary information to adequately assess the animal welfare aspects of the proposal and make a speedy determination on the acceptability of the research. Failing to work with the AEC process can lead to delays in approvals and suspension of projects for failing to meet reporting requirements.

Discussion – Project Documentation

Project planning – Proper consideration of all aspects of your proposed project will enable you to have a much better understanding of the information required to complete the AEC documentation in a satisfactory manner. One of the biggest mistakes investigators make is not allowing adequate timeframes for project and licensing approvals. This is a vital part of the planning process, and without making allowances for this it is very doubtful that a project will begin on time, as projects cannot start until AEC approval has been given. Please make sure you are familiar with the meeting dates of your AEC and the operation of the approvals process and factor that in to your project timeline.

Consider who will be responsible for the project. The Chief Investigator should be the person who has day to day responsibility for the running and management of the project. They also need to be the one who holds all primary licences and who has all the necessary skills and abilities to undertake the project and supervise and mentor other staff. They are also responsible for submission of all required reporting by the due timeframe and supplying the AEC with all requested information and clarification. All staff who will be working unsupervised on the project also need to have adequate levels of skills and abilities to ensure the welfare of any animals they may be dealing with. Any volunteers or staff without the necessary experience must be supervised at all times.

When considering the techniques to be used, it is preferable that best-practice guidelines be followed at all times. To assist investigators with understanding what is considered best-practice DEC has developed a series of Standard Operating Procedures (SOPs) that detail the approved methods and competencies for a range of common techniques used in fauna research. These SOPs can be downloaded from the DEC website at www.dec.wa.gov.au/content/view/5389/2058/ Techniques that are not covered by these SOPs may be considered but if it requires specialist skills or training, or involves a greater level of potential impact on the fauna involved the applicant may have to provide extra justification as to why this technique is the most appropriate.

New Project Applications – Written approval from the AEC must be obtained to use animals for scientific purposes. This includes research, fauna surveys, monitoring, translocation, captive breeding, collecting eggs and education / training. Information provided in the application must be sufficient to satisfy the AEC that the proposed use of animals is justified and that animal welfare concerns have been fully addressed. The application should also explain the expected value of the knowledge to be obtained and demonstrate consideration

of the 3 R's. All background and supporting documentation relating to the project should be provided with the application when submitted. This includes verification that all members of the team are competent at performing the tasks required, have all the necessary licences and endorsements and are able to reliably assess animal welfare for the proposed species.

Project Renewals – In the spirit of minimising the impact on animals handled during projects all projects need to be resubmitted for consideration by the AEC at least every 3 years if ongoing. Investigators are required to review projects and submit project renewals making sure to include information on any changes that have occurred. This includes project objectives, methodologies, refinements and updated staff competencies. The renewal should also include justification as to why the project needs to continue and a summary of results over the previous 3 years.

Project Amendments – All changes to the protocols, including animal numbers, type and procedures must be submitted to the AEC for approval. This may be done at any stage of the projects lifespan. If the changes relate to addition or removal of personnel and / or locations, please contact the Executive Officer to organise. This will generally not need to go before the AEC. Failure to seek AEC approval prior to making changes may result in the suspension of the project or other disciplinary action.

Project Reporting

There are three major areas of reporting under the Animal Ethics framework. These are fieldwork notifications, annual reports and unexpected animal death / emergency euthanasia reports.

DAFWA Fieldwork Notification – As part of the institutional licence conditions, notification of timing and location of all fieldwork activities for AEC approved projects must be submitted to DAFWA before fieldwork begins. Each approved project is required to submit this notification. DAFWA has instituted a proforma notification that may be obtained from the Scientific Licensing Officer.

Annual Report – Any project that has been approved to use animals is required to complete an annual report each year for the duration of the project, whether or not animals where actually used in that calendar year. These reports must provide a summary of progress and achievements, details of any problems, animal deaths and injuries as well as actions that were or could be taken to avoid the same problems in the future. Failure to submit an annual report may result in the suspension of the project.

Unexpected Animal Death / Emergency Euthanasia Report – The AEC must be notified as soon as possible of the event if any animal becomes terminally ill or dies unexpectedly. It is a requirement that you arrange a post-mortem of the animal unless you receive special exemption form the AEC or there are extenuating circumstances.

Conclusion

The aim of this presentation has been to increase understanding of the ethical considerations and operational guidelines for turtle research in WA, but it equally applies to any type of research involving animals. By gaining an understanding of the legislative underpinnings and framework of the processes involved it is hoped that researchers will come to understand that the AEC acts in the best interests of the Researchers as well as ensuring that animal welfare is given the consideration that it deserves. Rather than viewing the AEC as an obstacle to be overcome, Researchers should start thinking from the perspective that the AEC is there to ensure they have the best quality projects possible and to assist wherever possible in the smooth and effective assessments of scientific projects. By ensuring that any research is conducted with the highest degree of ethical consideration and within the best practice operational guidelines, Researchers will not only ensure that their projects will have minimal delays in being approved, but will also ensure the best possible outcome for the fauna being studied.

The Power of Citizen Science: Turtles of James Price Point – Engaging the Community and Filling the Gaps

*Madeline Goddard *, Tegan Mossop and Kevin Smith*

Walmadan Active Research Collective

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A volunteer community survey was conducted in collaboration with the traditional custodians, the Goolarabooloo people, and the Broome Community No Gas Campaign to investigate marine turtle nesting along the coastline near the site of Woodside's proposed Browse Liquefied Natural Gas (LNG) precinct, as it was perceived that the surveys conducted by Woodside for the Environmental Impact Assessment were inadequate.

14 nests and 38 false crawls were found from the species flatback, hawksbill and green turtles, with all nests and most false crawls occurring within the 6 km between Walmadan and the Gully. This stretch was exactly where Goolarabooloo elders said that all nesting would occur. Exhumations showed that nest egg numbers and success rates varied greatly. However, 6 out of 8 nests had over 42% of hatchlings successfully exit.

Photographs of one laying mother were sent away to confirm that the species was a hawksbill Three turtle experts agreed that the markings on the turtle suggested that it was potentially a hybrid with an olive ridley

Density of nests in the 6 km nesting area were lower than the average nest density from two monitored beaches near Broome. However, the study area was unique for the hawksbill nests which are rarely found in the Kimberley. The 14 nests and 38 false crawls greatly differed from the 1 nest and 2 false crawls previously found in the same area by RPS as part of the Environmental Impact Assessment for the proposed LNG precinct

Unfortunately, this high impact area coincides directly with the prime nesting habitat, meaning that much of the nesting habitat will be removed or altered. Although some of these impacts can be managed, the close proximity, cumulative stressors and loss of nesting habitat will most likely cause a significant impact upon local nesting behaviour and individual survivorship. The likely and significant impacts from the Browse LNG precinct on this significant population must be considered seriously, as Kimberley's marine turtle population is recognised as being of global significance (EPA 2010), and the inclusion of community members in the monitoring of their beaches under threat is an empowering and important way of gaining greater knowledge of the area.

Reference

Environmental Protection Authority (2010) Environmental Assessment Guideline for protecting Turtles from light impacts. Environmental Protection Authority, Western Australia pp. 27

Gnaraloo Turtle Conservation Program and Gnaraloo Feral Animal Control Program

Karen Hattingh[1], Paul Richardson[2] and Mike Butcher[3]*

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Introduction

Gnaraloo Station is a privately leased pastoral station and wilderness tourism business situated on the Ningaloo coast, adjacent to the Ningaloo Marine Park and the Ningaloo Coast World Heritage Area in Western Australia. It abuts 60km of coastline, including southern parts of the Ningaloo Reef and four marine sanctuary zones. The Indian Ocean borders Gnaraloo to the west.

Gnaraloo initiated the scientific Gnaraloo Turtle Conservation Program (GTCP) in 2005 to identify and protect significant rookeries of endangered sea turtles on its coastline. On-ground monitoring surveys commenced in 2008, along with the accompanying protective Gnaraloo Feral Animal Control Program (GFACP). Both programs are currently in their fifth season of operation and are privately funded by Gnaraloo Station and Animal Pest Management Services (APMS), with occasional contributions by the Australian Government. One of the primary objectives of the GTCP is to gather baseline data in order to establish long term trends of sea turtle activities onshore at Gnaraloo. Other objectives include biodiversity conservation, identification and protection of critical coastal nesting habitat of endangered marine species, training of scientific interns, engagement of community and school participants and increased public awareness of conservation issues. The GTCP operates under a seasonal research licence that is issued by the Department of Environment and Conservation (DEC) (Western Australia).

Methods

What is monitored?

There are currently two monitored areas, the Gnaraloo Bay Rookery (~7km) and the Gnaraloo Cape Farquhar Rookery (~14km), which are both located in the southern section of the Ningaloo Marine Park. Three sea turtle species, endangered loggerhead (*Caretta caretta*), endangered green (*Chelonia mydas*) and critically endangered hawksbill (*Eretmochelys imbricata*) turtles, have been recorded, with the survey areas containing predominantly nesting loggerheads.

Turtle nesting activities are monitored at the Gnaraloo rookeries from 1 November – 28 February, with 4 months of daily surveys of targeted beaches on foot (7 days/week, at times including day and night surveys) during each consecutive season. The tracking and monitoring methodology and protocols used are based on that of the Ningaloo Turtle Program in Exmouth. Field work includes daily morning surveys of (1) species identification through track interpretation and nesting activity determination (i.e. nests, unsuccessful nesting attempts, U-Tracks, Unidentified activities); (2) counts of nests and unsuccessful nesting attempts; (3) use of GPS equipment to record nest locations to determine nest density and distribution within the monitored areas; (4) data collection of nest disturbance by native and introduced predators and environmental factors; (5) for adaptive management purposes, independent monitoring of the effectiveness of the GFACP and (6) data management, analysis and scientific reporting which is provided to Government agencies (State and Australian), universities (country wide) and made publicly available on the Gnaraloo website. To ensure data QA/QC, in 2010/11 the GTCP introduced additional night surveys at the beginning of the season to identify margin of error and confirm accuracy of species identification and nesting activity determination by the seasonal scientific GTCP field research team.

The University of Western Australia conducted research in the Gnaraloo Bay Rookery during 2010/11 on climate change impacts on the sexing of sea turtle hatchlings ('Where are male Loggerhead turtles (*Caretta caretta*) produced in Western Australia?') and James Cook University (Queensland) investigated the issue: 'Nest site selection and climate change: how vulnerable are the Loggerhead turtles (*Caretta caretta*) nesting in Western Australia?'.

Results

What was recorded at the Gnaraloo Bay Rookery?

The Gnaraloo Bay Rookery is one of the two most significant mainland (as opposed to island) breeding rookeries for loggerheads in Western Australia (the other being in Cape Range National Park, Exmouth). The Gnaraloo loggerhead rookeries are the most significant loggerhead rookeries in the Ningaloo Marine Park and the Ningaloo Coast World Heritage Area and the research since 2008 by the GTCP to monitor such rookeries constitutes the baseline on loggerheads for the Ningaloo Marine Park. The Gnaraloo loggerhead population is part of the third largest loggerhead population in the world.

The summary table shows the number of sea turtle nests per species that have been recorded at the Gnaraloo Bay Rookery.

Summary Table: Sea turtle nests per species at Gnaraloo for period 2008/09 – 2011/12

		2008/09	2009/10	2010/11	2011/12
Loggerhead (*Caretta caretta*)	Number of nests	**329**	**402**	**402** range 358 – 446	**321** range 269 – 373
	Number of females	82 range 66 – 110	100 range 80 – 134	100 range 80 – 134	80 range 64 – 107
	Percentage species composition	90%	77%	94%	93%
Green (*Chelonia mydas*)	Number of nests	**9**	**30**	**8** range 7 – 9	**25** range 21 – 29
	Number of females	2	5	1	4
	Percentage species composition	2%	6%	2%	7%
Hawksbill	Number of nests	**20**	**78***	**2**	**0**
(*Eretmochelys imbricata*)	Number of females	8	31	1	0
	Percentage species composition	5%	15%*	0.5%	0%
	TOTAL NUMBER OF NESTS	**358**	**510**	**412**	**346**

Notes: * There is 0 – 20 Hawksbills per season. It is believed that there was a data collection error during 2009/10 when 78 nests were identified as hawksbills: which is why a new GTCP program component namely 'Data verification through night surveys' was introduced during 2010/11, 2011/12 and ongoing for data QA/QC.

What was recorded at the Gnaraloo Cape Farquhar Rookery?

The Gnaraloo Cape Farquhar Rookery was identified as a potential additional significant rookery on the Gnaraloo coastline during aerial surveys undertaken for the GTCP during 2009/10 and 2010/11. The first on-ground reconnaissance surveys of this rookery were undertaken during 2011/12. The surveys recorded the majority of nesting activities as loggerheads, but green turtles also used the rookery for nesting purposes. Turtles identified as greens (juvenile and adult) and smaller unidentified individuals were frequently observed swimming alongshore the rookery during the surveys which indicates that the loggerhead activities observed may not entirely describe the extent of turtle presence in the area by other species. The most significant achievements during 2011/12 were the identification, naming, delineation and mapping of this rookery and on-ground reconnaissance surveys of all its sub-sections for sea turtle activities. However, the majority of research questions concerning the Gnaraloo Cape Farquhar Rookery cannot yet be answered at this early stage of establishing baseline, including: (1) all turtle species that utilize the rookery; (2) the seasonal number of nests dug at the rookery; (3) sub-sections in the rookery with the highest turtle nesting activities; (4) the start, peak and end of the nesting period at the rookery; and (5) the relationship, if any, between the Gnaraloo Bay Rookery and the Gnaraloo Cape Farquhar Rookery which is located 22km to its north as it is possible that sea turtles use both locations for mating, nesting, foraging and/or resting purposes. Should this be the case, the recorded seasonal numbers of sea turtles at Gnaraloo may be an underestimation and the Gnaraloo rookeries may be more significant than previously known.

The GTCP Report 2011/12 will be released during December 2012.

For details of the GFACP, refer to the 'Gnaraloo Feral Animal Control Program Report 2011/12' which is available on request.

Who does the survey work?

The GTCP scientific internship program offers commercial project experience and professional development opportunities to the seasonal interns that work under the program, under guidance of the GTCP Project Manager, an experienced environmental scientist. Gnaraloo uses a comprehensive recruitment program for selection and appointment of the scientific interns who, as a minimum, need to hold a scientific degree. The interns work as the seasonal GTCP field research teams. They also receive training and undertake additional work at the regional office of the GTCP Project Manager, under direct supervision for up to 2 months, both pre-season and after the field work component ends at Gnaraloo (for essential program planning, development, data analyses, quality reporting and other required project activities). During 2012/13, Gnaraloo received over 80 applications from Australia and worldwide for the 4 scientific intern positions on offer, including numerous applicants with strong academic qualifications such as BSc and Masters degrees, previous sea turtle experience as well as other international project and field work. The seasonal GTCP field researchers includes a 'Community Co-ordinator' role (still with the requirement to hold a scientific degree) to facilitate involvement of community and school participants with the sea turtle research that takes place under the program.

The GTCP scientific interns receive pre-season training in WA turtle tracking protocols and practices by DEC Exmouth District and the Cape Conservation Group who together manage the Ningaloo Turtle Program in Exmouth. The training and assessment events occur in Exmouth and generally take 4–5 half days. The GTCP

undertakes an information exchange visit with DEC each season at Gnaraloo to share knowledge, results and program developments.

The Gnaraloo leaseholder and Gnaraloo site management teams (onsite at the Homestead area, including a professional mechanical workshop and services, 3Mile Camp and Perth) provide essential ongoing year round support to the GTCP.

What else does the GTCP researchers do?

The GTCP has an extensive environmental education and community outreach program, including a schools program. The GTCP provides presentations at primary and high schools in regional and metropolitan locations with informative learning to students (ranging from 7 – 17 years) about endangered sea turtles, research at Gnaraloo, conservation initiatives as well as scientific career information to older groups. It also hosts educational field excursions for student groups at Gnaraloo during the annual turtle season to participate with research under the program. Educational information flyers and site signage about the GTCP and GFACP are produced and displayed at Gnaraloo to encourage responsible behaviour by visitors on the Gnaraloo coastline.

National Marine Turtle Database

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Building on discussions and outcomes from the Marine and Coastal Committee, the Australian Coastal Ecosystems Facility (ACEF) is developing a National Marine Turtle Database. It aims to fulfil the need for national coordination of turtle data management and reporting across Australia. Currently, State and Commonwealth Governments and industry monitor turtles using a range of methods. Data are managed in separate databases by separate organisations and are not routinely or easily combined for analysis and reporting at a national level for a variety of purposes and uses. The Atlas of Living Australia (ALA) presents an ideal opportunity to host the National Marine Turtle Database in a recognised information system. The ALA's Biological Data Recording System (BDRS) is a highly flexible, configurable data system which will enable storage of field data from a variety of sources. The National Marine Turtle Database will allow data providers to maintain custody of their data on a secure, ALA supported system, while enabling custodians to determine who can access and view their data. ACEF will develop import functions to upload data from the various custodians into the central database. Additional functions will be available for national reporting.

Implementation of a Camera Monitoring Program for the Loggerhead Turtle (*Caretta caretta*) Rookery at Turtle Bay, Dirk Hartog Island, Shark Bay

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Shark Bay District has for the past 3 years been trialling the use of a remote camera for monitoring nesting at the Turtle Bay loggerhead rookery on Dirk Hartog Island in the Shark Bay World Heritage Property. The camera, a Mobotic M24, has been situated on the cliff line above the largest of the nesting beaches in the Turtle Bay nesting complex. The field of view of the camera encompasses approximately 50% of the available nesting area of this beach. Images of the beach are taken at regular intervals in the early hours of each morning during the nesting season. The quality of the images is high and individual turtle tracks can easily be identified and counted from the previous night's activities. Ground truthing of track counts has occurred during the 2009 nesting season. Issues with the camera have included complexity of the associated software, remoteness of the location and impacts from extreme weather conditions. Further trials will involve the use of smaller and more robust systems with greater numbers of cameras to cover more of the available nesting areas.

Community Monitoring, Conservation and Securing the Future of Flatback Turtles (*Natator depressus*) 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. The Kariyarra name for Port Hedland is Marapikurrinya meaning where five finger-like tidal creeks begin.

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. Many of the local Kariyarra people today, still have the turtle as their spiritual totem.

Much has changed in the Port Hedland area, particularly with the lifting of the iron ore export embargo in the late 1960s, so much so that the dredging and transformation of the mangrove harbour and an array of other mineral resources has in recent times lead to the Port Hedland harbour as being one of the largest bulk tonnage ports in Australia.

Today, with a population of 24,000 people, Port Hedland and its associated beach areas are a far cry from what they once were.

Each of the Port Hedland beaches represents a unique monitoring and management opportunity. 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 in the sights of a proposed residential development and if the plans are fully realised, will also be in the heart of a modern residential community. 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, Indigenous take and harbour dredging), residential lighting and feral animal predation. The monitoring methods used are based on a track identification method to determine the distribution and abundance of marine turtles during nesting. This was favoured as a non-invasive approach that allowed for a high level of community involvement. It also enabled the documentation of successful nests, hatchling emergence and any apparent disturbance such as nest predation by the European red fox, or human disturbance such as off road vehicles and inappropriate turtle interactions.

The project this year will be the program's ninth season and while still in its infancy the program has already been able to deliver quantifiable data that has been able to be implemented into management decisions, particularly in regards to the impacts of fox predation, land based recreational activities and proposed residential developments. It has also promoted the development and distribution of an array of education materials, including a Port Hedland specific "turtle watching code of conduct" that has acted to greatly raise awareness about flatback turtles and the threats to these local populations to local community and tourists.

Mangguru (marine turtles) and Balguja (dugong) Monitoring Project: Looking after Turtles and Dugongs on Wunambal Gaambera Country, North Kimberley

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Indigenous communities have increasingly been expressing their aspirations for the management of their marine and coastal environments through a process known as sea country planning. The Wunambal Gaambera Aboriginal Corporation, representing the Traditional Owner community associated with the Uunguu Native Title Determination, has chosen to create a "Healthy Country Plan", which was developed by the local Traditional Owners and establishes targets for monitoring and maintaining a healthy sea country, including marine species and habitats. In order for the plan to be effective, support for implementation is crucial, and research and data collection are essential components of many of the goals set out. This project is an example of participatory action research which incorporates effective, community-friendly data collection and mapping methods to monitor turtles and dugongs on Wunambal Gaambera country. Wunambal Gaambera Aboriginal Corporation, it's Uunguu Rangers the North Australian Indigenous Land and Sea Management Alliance, and CSIRO are collaborating through a project funded by the National Environmental Research Program to develop a new boat-based transect method for monitoring local marine turtle and dugong populations. Analysis of preliminary survey data shows that standard distance sampling methods can be applied to small-boat surveys of marine animals to obtain reliable estimates of their distribution and abundance.

Critical Habitats and Migratory Routes of Tagged Loggerhead Turtles (*Caretta caretta*) after Nesting at Ningaloo Reef, Western Australia

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The Ningaloo World Heritage Area provides part of the critical nesting habitat for the world's third largest population of endangered loggerhead turtles (*Caretta caretta*). This study aimed to gain an improved understanding of foraging areas and migratory routes of individuals nesting at Ningaloo Reef and consider threats to their conservation. Nine loggerhead turtles were fitted with KiwiSat Platform Terminal Transmitters (PTTs) using the Argos system following a nesting emergence in the months of December 2007 and January 2008. The tracked turtles ranged in size from 89.9cm to 104cm curved carapace length. Five turtles had successfully nested prior to PTT attachment. Data from the satellite transmitters was analysed using the Satellite Tracking and Analysis Tool (STAT) and GIS to better understand the turtles' movements. A home range analysis of the filtered satellite data was undertaken using Time-geographic Density Estimation (TGDE). The PTT's transmission period ranged from 57 to 689 days. For turtles that appeared to continue their nesting following tagging, intra-nesting intervals could be deducted from the data. Three different migratory patterns were observed: one turtle remained at Ningaloo reef within 50 kilometres from its nesting beach, two turtles travelled some 400km southward into the Shark Bay World Heritage area, with all remaining five turtles migrating north-eastward moving into nearshore and other neritic habitats off the Pilbara, Kimberley and Cape York coast. Three of the five turtles shared a migratory route from Ningaloo reef past Barrow Island until the Montebello Islands before changing routes. Critical habitats identified were considered in light of threats to their conservation. The home range of one turtle directly overlapped with the impact zone of the 2009 Montara Oil Spill in the Timor Sea. This study highlights the geographical extent of the critical habitats utilized by endangered loggerheads and the need for adequate conservation measures to be applied.

Satellite Tracking of West Kimberley Flatbacks: Eco Beach and Eighty Mile Beach

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Introduction

The West Kimberley region of Western Australia supports significant populations of flatback turtles *(Natator depressus)* which occupy a wide range of marine habitats. Our focus annually is on monitoring nesting flatbacks in this region at Cable Beach, Eco Beach and Eighty Mile Beach. We began deploying Platform Terminal Transmitters (PTT) on nesting flatbacks in 2009 at our Eco Beach program and have continued annually at this location with deployments. This presentation gives an overview of the spatial distribution of 14 flatback turtle movements, from nesting to foraging grounds in Western Australian waters between Ningaloo to the south and the Timor Sea to the north.

Methods

14 PTTs have been deployed to date with more planned. No PTTs had been deployed from Eco Beach prior to Conservation Volunteers Australia (CVA) commencing this tracking in 2009. We started flipper tagging, marking nests and conducting nest exhumations a year earlier in 2008. Because flatbacks lack keratin in their carapace, a specially made harness is used to attach the PTT, as opposed to using epoxy resin to glue the PTT directly to the carapace. This work is ongoing but two types of PTTs have been used to date to track flatbacks – KiwiSat 101 from Sirtrack and Mark 10 AF Fastloc transmitters from Wildlife Computers. Both types were deployed during 2011. As far as we are aware, CVA was the first group to deploy PTTs on nesting flatbacks at Eighty Mile Beach. This commenced December 2011 with six deployments. Most of our tracked turtles have been named by school students, with a number of tracking competitions operating. Mapping results can be viewed by the public on www.seaturtle.org.

Results

One of the early Eco Beach deployments, Lucy Roscoe, had her PTT go offline a number of times during her tracking. She survived Tropical Cyclone Laurence in December 2009 just after completing her nesting season. Although the PTT batteries died on her way back to Eco Beach, she did complete a one year nesting cycle, as her harness drag marks were seen on the beach 16 days later.

Lucy Jack's PTT went offline after 81 days early 2010 and then recommenced transitions nine months later, eventually lasting a total of 541 days. This is the longest any of our PTTs have transmitted to date.

There is a considerable gap in data and potential migratory locations during these missing nine months.

One of the 2011 Eco Beach deployments, Lesley, is the only tracked flatback to date which hasn't left Roebuck Bay and the nearby nesting beach. She was named in memoriam of Lesley Baird of Broome and Chelonia Wildlife Rehabilitation & Release.

Trash has also stayed local to Eco Beach but slightly to the south and has travelled the least straight line distance of any of the turtles at 46km. By comparison, Shelly from Eighty Mile Beach has travelled the furthest to date at 1,020km in a marine straight line. The most any of the 14 turtles has travelled in total distance (much of it in circles foraging) is 9,667km over 433 days of transmissions.

If we look at exactly where the 14 flatbacks are foraging (Figure 1), some migrated to the known Holothuria Banks in the Timor Sea. Holothuria means sea cucumbers, starfish and other symmetrical invertebrates. The second foraging area we have referred to geographically is around Adele Island. The next area is West Dampier Peninsula. Finally, a number of turtles forage in an area we've called Cape Gourdon,

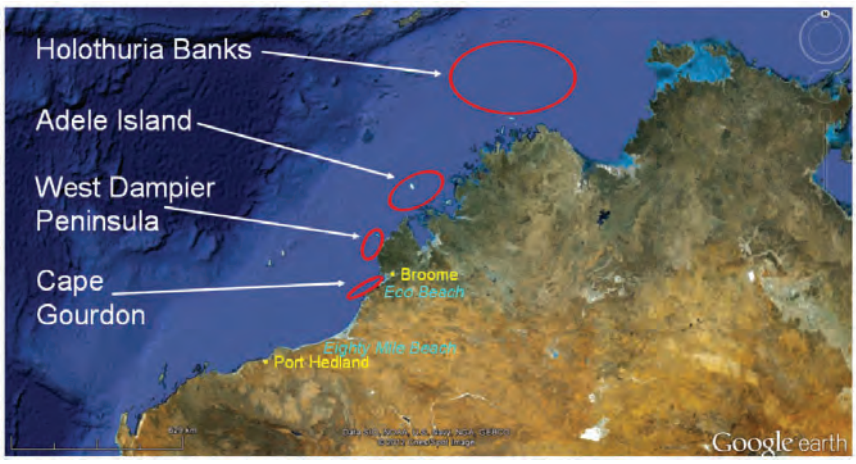

Figure 1. Identified flatback foraging grounds

Eco Beach Eighty Mile Beach

Foraging grounds:

	Holothuria Banks	*Adele Island*	*West Dampier Peninsula*	*Cape Gourdon*
1	Lucy	SeaMore	Kurlibil	Lesley
2	Lucy Roscoe	*Miss Kimberley*	*Miss Kimberley*	Trash
3	Shelly	Great Turtle	*Lucy Jack*	*Lucy Jack*
4			*Paddles*	*Paddles*
5			Archie Pelago	
6			Millie	

Figure 2. Flatback foraging ground associations

representing from central Roebuck Bay down to Gourdon Bay.

Figure 2 shows a sharing of foraging grounds by Eco Beach and Eighty Mile Beach flatbacks. Three turtles (Miss Kimberley, Lucy Jack and Paddles) spent considerable time in one foraging ground, before moving on to another. At the time of writing, Paddles had just reached her third foraging ground, that of Adele Island, but is not listed here as she may just be passing through.

Great Turtle's movements from Eco Beach and the one missing from the table in Figure 2, Jack, need to be examined further (Figure 3). After finishing her nesting season at Eco Beach, Great Turtle moved to the Adele Island foraging ground for more than four months. She then moved on and has continued foraging at the very bottom of Collier Bay. Jack, our only turtle that headed south, left Eighty Mile Beach to forage around North and South Muiron Islands near Ningaloo.

Conclusions

- All Eco Beach turtles stayed locally or headed north to forage
- All Eighty Mile Beach turtles, except one, headed north to forage
- A single flatback may share foraging grounds in West Kimberley coastal waters of the Indian Ocean and in the Timor Sea
- Both Eighty Mile Beach and Eco Beach flatbacks are sharing foraging grounds
- Flatbacks forage in sometimes deeper waters as well as shallow, more turbid waters
- Mapping of the tracked turtles has identified multiple foraging grounds along the West Kimberley coastline. Individual turtle migratory results show that many flatbacks are sharing foraging grounds and a single individual may move between three of the four identified. Both the Eco Beach and Eighty Mile Beach nesting beaches, located 250km apart, have turtles sharing the same foraging grounds. It is interesting to note that while the Eighty Mile Beach flatbacks are nesting at the same time as Eco Beach turtles and passing by, our Eco Beach program to date has not located a flipper tag return from any other tagging program.
- Further research and data analysis is required for these two important flatback nesting beaches.

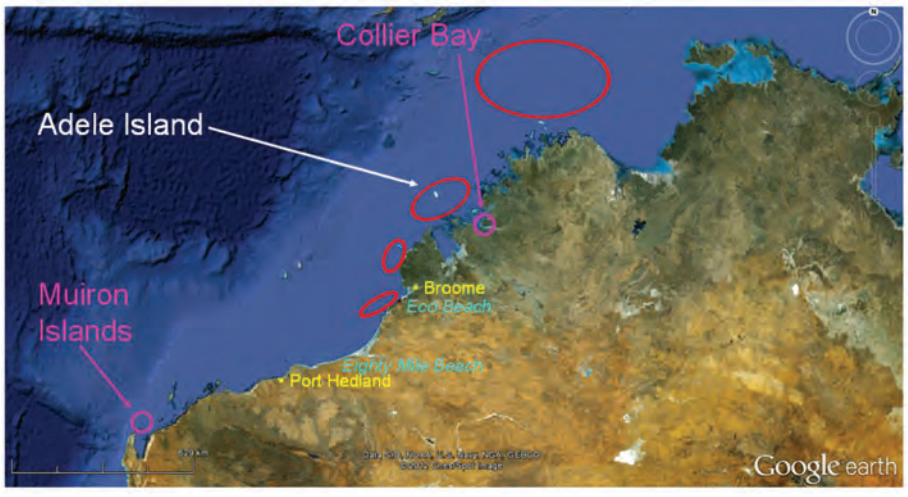

Figure 3. Additional flatback movements

Modelling Sand Temperatures and Sex Ratios in Marine Turtle Nests: the Challenges and Applications

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Understanding how the sex ratios of hatchling turtles vary in space and time, and under novel circumstances such as climate change, is critical for conservation planning. Several methods have been developed that correlate nest temperatures with nest sex ratios, but extrapolation of correlative models beyond the boundaries of the data used to generate the relationships can produce misleading outcomes. Instead, mechanistic models based on a first-principles model of the nest microclimate and on the thermal physiology of embryos, offer a flexible and unbiased way of exploring patterns of sex ratio variation. We have been applying a mechanistic modeling program called Niche Mapper™ to predict the hatchling sex ratios of Western Australian (WA) Flatback and Loggerhead turtles. Niche Mapper™ combines a microclimate model of soil temperatures – based on topography, solar radiation, physical properties of sand, and the local climate – with a physiological model of an ectotherm. Population-specific parameters such as embryonic development rates, pivotal temperature (Tpiv), and the thermosensitive period (TSP) are integrated with the microclimate model's soil temperature profiles to estimate the sex ratio of a nest at a particular location. These physiological parameters have been quantified over several years of laboratory incubation experiments at UWA, using Flatback turtle eggs sourced from the Pilbara (Bells Beach and Delambre Island) and Loggerhead turtle eggs from Gnaraloo Bay and Turtle Bay on Dirk Hartog Island. Preliminary models of sex ratios expected along the coastlines relevant to each species have also been generated, as have predictions of future sex ratios under a range of climate change scenarios.

A major challenge to date has been our ability to adequately test our models with empirical measures of sex ratios at various WA rookeries. Nest destruction due to disturbance, predation or storm surges associated with cyclones Bianca and Iggy have largely thwarted our attempts to collect mature embryos from nests for sexing. Other challenges include the model's dependence on terrestrial climate surfaces for predicting coastal conditions, and the availability (and cost) of high resolution digital terrain models for assessing the importance of beach aspect on nest temperatures. Once properly validated, mechanistic models will provide a non-invasive method for assessing current sex ratios, and will have virtually unlimited applications for examining key embryonic processes at a range of spatial scales.

Bardi Jawi Marine Turtle Management

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The Bardi Jawi People of the Dampier Peninsula have been involved on and off in traditional western science management of marine turtles since the late 1980's. Today they have secure funding for the Bardi Jawi land and sea rangers and are about to declare an Indigenous Protected Area (IPA) over their traditional lands, which will set the direction for future management and partnerships. The Bardi Jawi continue to work in the area of marine turtles as these important species still play a key part of their culture and tradition. This presentation will communicate turtle monitoring data on the Dampier Peninsula for the last few years and also future plans to manage the species through the IPA in a culturally appropriate way.

Preliminary Assessment of the Genetic Profile of the Western Australian Loggerhead Turtle Population using Mitochondrial DNA

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Genetic studies are fundamental to assess the viability of a wildlife population, and to develop appropriate management and conservation actions. Additionally, genetics can assist in the identification of population substructure and demographic changes over time. As a result of these powerful applications, genetics has been widely applied in sea turtle research with the primary goals of identifying breeding and foraging populations, as well as determining geographic ranges and possible migratory routes. Despite the fact that the Western Australian loggerhead turtle (*Caretta caretta*) population is considered amongst the largest in the Indian Ocean, there is very little information available on the genetic profiles of nesting and foraging sites along the Western Australian coast line.

Samples were collected from three different sites throughout the loggerhead turtle distribution range in Western Australia: a nesting ground in Cape Range National Park and the nesting and foraging grounds in Shark Bay. A partial sequence of the control region (n=76) of mitochondrial DNA (mtDNA) and eight (nuclear) microsatellite loci (n=86) were successfully amplified. Results from the analyses of mtDNA are presented. We found high levels of genetic diversity. In fact, five different haplotypes, based on ~380 bp sequences, and nine haplotypes, based on ~740 bp sequences, were identified. The haplotype diversity was 0.499 (SD 0.04) for the short alignment and 0.608 (SD 0.04) for the longer alignment. We will compare these results to other published studies on loggerhead turtles in the Pacific Ocean and discuss the phylogenetic relationship of the haplotypes found in this study with haplotypes known to occur in other loggerhead turtle populations.

Managing Marine Turtles on Barrow Island: an Industry Perspective

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This talk focuses on the lessons learned by Chevron Australia to manage the potential risks of a development to a population of flatback turtle (*Natator depressus*) on Barrow Island. Key experiences and lessons are shared so that future practice in working in areas with marine turtles by other organisations can be considered and applied.

A large population of flatback turtle nests on Barrow Island (Western Australia) where construction is underway for a major liquefied natural gas processing facility. Long-term monitoring of marine turtles has been mandated by the Federal and State governments to assess potential impacts on this turtle population during the construction and operation phases of the facility.

One of the challenges of executing a Marine Turtle Program was to develop confidence within the Company and among internal and external stakeholders that early impacts could be diagnosed should these occur and that processes were in place to manage these. However, Chevron Australia was careful to avoid monitoring 'laundry lists' of parameters but alternatively, to design monitoring effort and apply questions strategically that address functional answers to assist the Company to understand its risks and impacts to turtles.

With advice from marine turtle population modelers, Chevron Australia is using time-series control charts as a decision-aiding tool to diagnose anomalous variations in key demographic parameters for the flatback turtle population that nests on Barrow Island and to annually diagnose the cause(s) of observed variation. These control charts illustrate and interpret trends in a population over time and link the information to management triggers that can inform managers when to act. Identifying a change offers managers the opportunity to make informed decisions about impact versus natural variation from an evidence-base. This is the first example of a comprehensive control-chart-based monitoring and management scheme being used for an endangered marine species that is exposed to a major construction project. Where data for a parameter deviate beyond these limits, then management is initiated based on a tiered alert, review or action trigger level to diagnose the deviation based on the available evidence and other control-charted parameters.

Chevron Australia can share the following learnings from its experience of managing the protection of marine turtles using Barrow Island whilst planning and implementing the construction of its gas facility:

Adaptive management. The Long-term Marine Turtle Management Plan (Chevron Australia 2012) focuses on the perceived risks to turtles during construction and operations of the Gorgon Project, and then on mitigation and management measures to reduce these risks to as low as reasonably practicable. Continuous improvement underpins the turtle management.

Early stakeholder engagement. Early involvement of a Marine Turtle Expert Panel, and additional scientists, helped Chevron Australia understand the questions pertinent to driving the flatback turtle monitoring program. Central to the development and use of a Long-term Marine Turtle Management Plan was the early consultation and engagement with key stakeholders to produce the Plan; in particular expertise gained from members of the Marine Turtle Expert Panel and subject matter experts in marine turtles. Continuing this engagement also built a level of trust among and between these key stakeholders.

Early baseline data collection. Up to five seasons of baseline (pre-construction) data have allowed Chevron Australia and its stakeholders to understand the variation inherent in population parameters collected annually that can then inform impact assessment during monitoring.

Foster environmental awareness and cultural change. Central to implementing the Long-term Marine Turtle Management Plan has been explaining to the island community why we need to minimise impacts to turtles through a variety of practices (e.g. light emission reduction, beach access restrictions, reporting requirements). Awareness among the workforce has improved by explaining in lay terms the predicted impacts to turtles (including hatchlings) of various activities.

Robust yet fit-for-purpose monitoring programs that are linked to the construction and operational risks, and that consider: the staged life cycle of the marine turtle and vulnerable life cycle stages relative to the risks understanding trends over the long term for a long-lived species comparisons between potential impact and reference sites scientific design and documentation of the programs use of control charts to identify early signals of change (the 'evidence'), and where monitoring is linked to an ensemble of 12 demographic variables for the species

Establish clear principles that underpin the management plan, and clear objectives for the monitoring programs whilst maintaining operational flexibility. Marine turtle field work is inherently difficult to logistically organise and execute, and particularly so within a region that experiences tropical cyclones. Monitoring programs have been implemented and are documented in a manner that meets their respective objectives whilst retaining operational flexibility to complete them.

The success of the Gorgon Project Marine Turtle Program has been possible because of the involvement of the right level of subject matter experts during the development and execution of these programs, and the commitment to embrace the science early within the environmental impact assessment process. The involvement of all

members of the Marine Turtle Expert Panel, comprising industry, government and independent experts, has played a significant role in ensuring that potential impacts have been minimised to the greatest extent possible, that a robust monitoring program is in place to detect any impacts that may eventuate so that appropriate management can be instigated, and that appropriate research programs are in place to fill knowledge gaps. Furthermore, the development of a Long-term Marine Turtle Management Plan may provide a precedent for future scenarios where development needs to be balanced with a high level of environmental protection for these species. Our application of the science, and the way we apply adaptive management to learn from the collection of this biological information, can be extended to other locations where industry and nature conservation co-exist.

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Marine Turtle Nesting Activity in the Pilbara Region and Southern Kimberley in Western Australia: Combining Survey Techniques to Describe Remote Habitats

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Little is known about the biology and ecology of marine turtles in the Pilbara region of Western Australia. Much of the Pilbara is considered remote and access to potential or known marine turtle nesting areas is limited. We confirm species-specific nesting activity at multiple previously unassessed island and mainland locations in north-western Australia and findings represent the first broad-scale overview of contemporary abundance and distribution of flatback, green and hawksbill turtles in this region. Twenty three sites (11 island and 12 mainland) from Urala to the northern end of Eighty Mile Beach were surveyed between December 2008 and January 2012 during the peak nesting period for each species. Flatback turtle nesting activity was widespread across both coastal and mainland survey sites. Substantial rookeries were identified at Barrow Island, Cemetery Beach, Port Hedland, Delambre Island, Dampier, Eighty Mile Beach, southern Kimberley and Mundabullangana station and cumulatively other sites within the region may represent additional and significant rookeries for this species. Green turtle nesting activity was identified primarily on outer islands away from the mainland with little or no activity at mainland sites. Activity was concentrated on Barrow, Boodie, Middle, Serrurier and Thevenard Islands. Hawksbill turtle activity was documented on islands only; no mainland nesting was observed.

A Novel Methodology for Measuring the Impact of Anthropogenic Light on Hatchling Orientation

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Marine turtle hatchlings typically emerge from the nest at night, and upon reaching the surface, make their way to the ocean. In the absence of interfering factors, they will generally take the most direct route towards the sea. This sea-finding ability can be disrupted by the presence of artificial lighting, such as street or building lights. This is because marine turtle hatchlings exhibit positive phototaxis; when exposed to a light source, they will move towards it. Anthropogenic lighting can cause hatchling misorientation (hatchlings move in the wrong direction i.e. not seaward) or disorientation (hatchlings wander in random directions, circling aimlessly). This can result in increased risk of death by predation or desiccation.

Measuring the impact of anthropogenic light on hatchling sea-finding ability is an important tool for marine turtle biologists. A novel method for monitoring hatchling orientation was developed by Pendoley Environmental based on work by Salmon & Witherington (1995) and Pendoley (2005). As hatchlings emerge from the clutch and move towards the ocean, their tracks disperse from the central point of the nest cone, creating a 'fan' pattern. In this new methodology, the outside 'arms' of the fan are measured to determine the degree of dispersion (spread angle). The orientation of the tracks relative to the most direct line to the ocean (offset angle) is determined by calculating the angle between the most direct line to the ocean and the bearing bisecting the spread angle. The degree of spread and offset can be used to determine the influence of nearby light sources causing hatchling misorientation.

This methodology of measuring hatchling orientation has been used in a number of resource industry projects by Pendoley Environmental to quantify the impact of artificial lighting on emerging marine turtle hatchlings. Baseline values (where available) can be compared to data collected during the construction and/or operational phases of a project. These results can be used to guide marine turtle management strategies and mitigate the effect of industry lighting on marine turtle populations.

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Reproductive Biology of Flatback Turtles in Western Australia

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This presentation provides important baseline information on the breeding biology of flatback turtles at three rookeries in Western Australia and identifies significant differences between island and mainland rookeries. Barrow Island and Mundabullangana (Pilbara region, Western Australia), support substantial flatback turtle (*Natator depressus*) populations, with 3,976 turtles recorded between 2005/2006 and 2010/2012 at Barrow Island and 3,386 at Mundabullangana. Cemetery Beach, near Port Hedland, is a smaller rookery with a total of 361 flatback turtles recorded between 2009/2010 and 2010/2012. The mean remigration interval at Barrow Island (1.7 years) was significantly shorter than the mainland Mundabullangana rookery (2.6 years) and this may reflect differences between the behaviour and habitat use of internesting turtles at the mainland versus offshore islands. Clutch size was similar between the three flatback rookeries (~47 eggs), but smaller than mean clutch size recorded for all other Australian flatback rookeries. Hatch success at Barrow Island (83.4 %) was within the reported range for the species; however, Mundabullangana and Cemetery Beach recorded the lowest hatch success (68.2 % and 57.3 %, respectively) published to date. This may be due to high temperatures experienced during incubation at these mainland rookeries.

Turtle Connections: Turtle Identification, Flipper Tags, 'Post-cards' to the Unknown, and Third Party Engagement

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Turtles don't have birth certificates and cannot tell you their name. If you are not familiar with marine turtles, see one, and want to know what species it might be, there are published key documents that will help. 'Saltwater' people for whom turtles are a cultural and economic resource further consider turtles from that perspective.

However, if you want to know more about the turtles' biology, life histories and population dynamics it is necessary to positively identify individuals from the target population and have that association of turtle and identification device or devices persist for the time needed for acquiring the information needed for the study.

Studies involving hatchling or juvenile turtles pose their own special problems due to the size of the turtles in the first instance, and their continuing growth. Adult size turtles pose lesser problems in these respects and have more often been the focus of extended study.

Non-corrodible external flipper tags when properly applied are the longest lasting lower cost means of individual turtle identification in general use. Embossed with unique character combinations of letters and numbers combined with project contact addressing, and applied externally, no special equipment is required to record and report observations wherever the tagged turtle may go and be found away from the project site.

Valuable information on dispersal range, the nature of the observation being reported, and the fate of the turtle involved can be obtained from these third party encounters. It is nevertheless known that people who may be discovering tagged turtles might not be looking out for tags, that some people finding tags might consider them indicators of ownership where reporting a find could be self incriminating, that reporting a particular type of encounter such as fishery bycatch or other industrial activity interaction otherwise unobserved might lead to other perceived detriment. Discoverers who do choose to report finds sometimes misreport necessary detail which cannot be recovered after the event.

The discoverers providing good records do contribute knowledge which adds value to the accumulated case history of the individual turtle involved. Acknowledging and rewarding those contributions is an essential part of any project. Ensuring as far as possible that responses are culturally appropriate is also important where hunter engagement is involved. Distant dispersal interaction records and turtle fate data is one set of information discoverable from studies including individually identifiable turtles readily detectable as such by third parties. This was anticipated at commencement of the Western Australian Marine Turtle Project Advisory leaflets were produced and widely distributed at regional scale from the outset. A Bahasa Indonesia translated version complemented the English language original. These of course anticipated literacy of potential discoverers and reporters and their confidence in making contact with perceived authority.

The first tag discovery report we received was from a green turtle tagged and released from an independent Papua-New Guinea project! The first WA-series tag discovery report was provided from Croker Island, NT, hunters early April 1987 for a green turtle tagged and released with assistance from Bardi community men from the first field program work late November 1986 on the West Island, Lacepede Islands, nesting beach. Since those first reports we have received many more for WA tagged turtles having ranged over a wide geographic area from SW WA to Indonesia and across into Torres Strait. Elapsed times between initial tag and release and encounter reports have ranged from ca 4 months to more than 20 years.

So, how might we visually present and distribute summaries of these data, and what might be made from those? At the first it was only possible to hand draw maps and indicate where turtles of different species and study groups may have been discovered. More recently it has become possible using GIS capabilities to estimate and plot minimum at sea distance dispersal tracks and to aggregate those to show the relative strength of linkages between recovery locations and nesting beaches in particular.

Rio Tinto Cape Lambert – Turtle Management Program

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Rio Tinto operates an iron ore handling, processing and ship loading facility at Cape Lambert. Marine turtle management plans (MTMP) were developed for a recent expansion of existing Cape Lambert operations, as well as for construction and operation of Cape Lambert Port B. Additional monitoring is also carried out under a federally approved Ecosystems Monitoring and Research Program (ERMP).

Potential impacts addressed in the turtle management program include:

Noise/vibration impacts, particularly during piling works;

Light spill from operations, and during construction;

Increased vessel traffic; and

Increased human disturbance of nesting beaches.

Turtle management at Cape Lambert focuses on two 'impact' beaches on the mining lease – Bells Beach and Cooling Water Beach. The turtle management program also includes annual monitoring at off-lease beaches in the region. Both on-lease beaches have been the target of an ongoing community monitoring program (West Pilbara Turtle Program, in partnership with Rio Tinto and the Department of Environment and Conservation; Speirs et al., this Symposium), with track counts recorded since 2005. In 2008, more comprehensive monitoring at these, and off lease beaches, commenced.

Rio Tinto's turtle management program now covers a range of activities under the existing MTMP and ERMP, including:

- Flipper tagging;
- Monitoring hatchling success and orientation;
- Monitoring of light and vibration levels at nesting beaches;
- Sand and in-nest temperature monitoring; and
- Analysis of satellite tracking data to examine internesting intervals, foraging, and movement among different beaches.

Seafood Guides and Certification: Sustainable for Marine Turtles?

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Introduction

As many as 50 different seafood cards and certification schemes around the world now attempt to provide advice to fish eaters about choosing the most "sustainable" fish. While well intentioned, they are undermining conservation efforts to reduce bycatch of sea turtles in commercial fisheries by rewarding unsustainable fishing practices. Each year hundreds of thousands or even millions of sea turtles globally are captured and killed as bycatch in commercial fisheries primarily in trawl, gillnet and longline fisheries for shrimp, swordfish and tuna – even with use of Turtle Excluder Devices (TEDs), circle hooks and other fishery regulations. Ranking fish from these high bycatch fisheries as "green" or "good alternative" or "certified sustainable" does a disservice to conscientious fish eaters, endangered species and fisheries. A review of Australian and U.S. seafood schemes exposes the need for revisions in the rankings to reflect the level of harm to sea turtles and to discourage consumption of fish from high-bycatch fisheries.

Methods

Seafood rankings for trawled shrimp and longlined swordfish and tuna from popular Australian and U.S. seafood guides were reviewed and compared to show the inconsistencies. We then highlighted the need to revise the rankings to flag high levels of sea turtle bycatch.

Discussion

Seafood consumer guides are proliferating worldwide:

- Blue Ocean Institute-Guide to Ocean Friendly Seafood
- Environmental Defense Fund
- Natural Resources Defense Council
- Marine Conservation Society-Fishonline (United Kingdom)
- Sea Choice-Canada (Canada)
- Monterey Bay Aquarium-Seafood Watch
- StarChefs' Sustainable Seafood Guide
- Australian Sustainable Fishing Guide
- Food and Water watch Smart Seafood Guide
- WWF International Seafood Guides-2007
- Greenpeace- US Red List
- Greenpeace- Canada Red List
- Greenpeace- International Red List
- Australian Marine Conservation Society

Additional resources:

- Seafood Choices Alliance
- Sustainable Fisheries Partnership- FishSource
- New England Aquarium Sustainable Seafood Program (U.S.)
- NOAA Fish Watch (U.S.)
- Noordzee Foundation, Goede Visgids (The Netherlands)
- Vancouver, British Columbia Aquarium Oceanwise Program
- Shedd Aquarium, Chicago, Right Bite Program
- Long Beach Aquarium of the Pacific, Seafood for the Future
- Fish Wise
- Fish Choice

The problem with the consumer guides is that in many cases they advocate for fish species caught in fisheries with high or relatively significant (to the particular sea turtle population) levels of marine turtle bycatch. In particular, trawl, gillnet and longline gear targeting wild prawns and shrimp, swordfish, tuna and shark continue

Figure 1 Sample Seafood Guides

to take a devastating toll on marine turtle populations in the U.S., Australia and around the world:

Worldwide ~ 8 million marine turtles captured in commercial fisheries between 1990–2008 (Moore 2009)

Global Longline Fishery (Swordfish and Tuna) ~ 55,964 turtles captured 1990–2008 (Moore 2009)

U.S. Shrimp Trawl Fishery ~ Each year 534,756 interactions, 52,534 mortalities; – 98 percent of U.S. turtle bycatch is in shrimp trawl fishery (NMFS 2012, Finkbeiner 2011)

Australia – Prawn Trawl Fisheries – Turtle ByCatch Reduced by Turtle Excluder Devices (TEDs) – required in Queensland in 2000 – Total bycatch unknown – data primarily from logbooks – unreliable?

Western Australia – TEDs use is a condition of permit and operation, but not in regulations. Observer coverage low. Total bycatch of turtles unknown, but endangered leatherback capture is documented

While TEDs can achieve nearly 100 percent success rates in freeing live turtles from trawl nets, poor compliance, observer coverage and enforcement has reduced effectiveness to as low as 30 percent in the U.S. Gulf shrimp fishery. Longlining remains a significant source of turtle mortality – even with circle hooks required in a limited number of U.S. fisheries for swordfish and tuna. A fishery should not be considered sustainable if it continues to take harmful levels of protected marine turtle populations, or where there is no data to support assertions of sustainability. It only encourages the continued over-exploitation of marine resources.

Marine Stewardship Council – Sustainable?

The Marine Stewardship Council has been criticized by marine conservation groups and fisheries scientists for certifying as "sustainable" fisheries that are not truly sustainable**.** Recently the Northwest Canadian and U.S. Southeast Atlantic Florida pelagic longline fisheries for swordfish received the MSC "eco-label" even though thousands of loggerhead and leatherback sea turtles are captured and injured or drowned in the fisheries every year. The MSC and organizations that issue seafood guides will lose credibility and effectiveness if they continue to downplay the significance of the loss of endangered, threatened and protected species as bycatch. Here are some of the turtle take levels in MSC certified fisheries:

U.S. Southeast Pelagic Longline Fishery for Swordfish – 147 loggerheads and leatherbacks taken per year (MSC and NMFS).

Canadian Pelagic Longline Fishery for Swordfish – 1,200 loggerheads and leatherbacks taken per year (MSC and NMFS)

Australian Northern Prawn Fishery is Under MSC Review for Certification: – Take of sea turtles reduced from 5000–6000 individuals in 1989–1990 to 30 to 50 per year (logbooks) (MSC 2012). However, the population is not recovering and sea turtle researchers have identified a decline in recruitment of juveniles and subadults that is likely to reverse the upward nesting trend in the next decade (Limpus 2010).

West Australian Rock Lobster Fishery – This fishery was the first to be certified by the MSC and remains certified even though recruitment to the fishery continues to decrease along with the size of the fishery.

Now that the Florida longline swordfish fishery has been certified, the entire U.S. Atlantic surface longline fishery is moving toward certification. This is the same swordfish fishery that collapsed in the 1990s and triggered the successful "Give Swordfish a Break" restaurant and public campaign that forced a closure and fishery reform.

Loggerheads and leatherback sea turtles are the species most often hooked and harmed or killed in the Atlantic pelagic longline fishery for swordfish and tuna. Between 2001 and 2008, the pelagic longline fleet snared 4,839 loggerheads and 6,626 leatherbacks for a total of 11,465

Figure 2. Loggerhead on longline vessel (*Oceana/Mar Mas photo*) and U.S. seafood counter (*Photo by Ellen November*).

Seafood Guide	Wild Prawn /Shrimp *Trawl w/TEDS*	Swordfish *Surface Longline*	Tuna *Deepset Longline*	Turtle- Safe Recomendation
Australian Marine Conservation Society	Think Twice	Say No	Say No	Prawn – Say No
Greenpeace Australia	Red List	Red List	Red List	OK
Seafood Watch (Monterey Bay Aquarium)	Avoid-imported/ US – Good Alternative	Avoid-imported/ US – Good Alternative	Avoid-imported/ US – Good Alternative	Avoid all
Blue Ocean Institute	Green	Light Green		Red
Food and Water Watch	Recommend U.S. Gulf	Don't Recommend	Don't Recommend	Don't Recommend US Shrimp
Environmental Defense Fund	Eco-OK – US/Can Eco – Worst - Imported	Eco-OK US Eco – Worst - Imported	Eco-OK – US/Can Eco – Worst - Imported	Eco-Worst
Natural Resources Defense Council	Not a Best Choice – US better	Not a Best Choice – US better	Avoid	Avoid all
Marine Stewardship Council – U.S. fisheries	Gulf shrimp fishery under review for eco-label	Florida Swordfish certified, Canadian NA certified, US NA next		Do Not Certify/DeCertify
Marine Stewardship Council Australia fisheries	Northern prawn fishery under review			Do Not Certify Northern Prawn Note: Spencer Prawn fishery is certified (no turtles)

Figure 3. Seafood Guides and Certification – Most Not Turtle-Safe

animals. Critically endangered Kemp's ridleys, hawksbills and green sea turtles are also caught in lesser numbers in this fishery every year. [NMFS SAFE Report 2009] National Marine Fisheries Service estimates that 635 loggerheads will still be harmed or killed in the Atlantic pelagic longline fishery every year even with circle hooks and other bycatch reduction measures, and that this impact remains a significant threat to the recovery and survival of the species. [Federal Register Notice, March 2010].

As a result of certifying unsustainable fisheries, the MSC has been hit with bad press around the world, with headlines that undermine consumer confidence in the scheme:

Sustainable fish customers 'duped' by Marine Stewardship Council

Certification granted to controversial fisheries has prompted severe criticism of the sustainable fisheries organization – The Guardian (U.K.) January 6 , 2011

Richmond biologist quits MSC over sockeye certification

(A) Richmond biologist is resigning from a Marine Stewardship Council stakeholder panel over its certification of Fraser River sockeye – Richmond News July 30, 2010

Seafood Stewardship Questionable, Experts Argue

The world's most established fisheries certifier is failing on its promises as rapidly as it gains prominence, according to leading fisheries experts from the University of British Columbia (UBC), Scripps Institution of Oceanography at the University of California at San Diego and elsewhere – Science Daily, September 1, 2010

Results and Conclusions

Not Turtle Safe? Not Sustainable!

Australian seafood guides reviewed ranked the highest bycatch fisheries for shrimp, swordfish and tuna as "red" or "avoid." In contrast, U.S. schemes ranked U.S. caught

shrimp, swordfish and tuna as "green" or "good alternatives" and most imports as "red" or "avoid." Nevertheless, U.S. and Australian and other commercial around the globe fisheries remain deadly to sea turtles, even with improved fishing gear. Seafood guides and certification programs must not recommend or label seafood as green or sustainable if the fish is caught with gear that harms or kills sea turtles. The following steps need to be taken:

1. Flag levels of turtle bycatch by fish species on seafood cards for all fish species with colour-coded icons of green (no turtle bycatch), yellow (rare, if any turtle bycatch), red sea turtles (turtle bycatch).
2. Revise the criteria for seafood guides and certification schemes to prioritize bycatch of endangered and threatened sea turtle species as negative to sustainability.
3. Do not recommend, certify or award eco-labels to fisheries or fish species caught with fishing gear that results in bycatch of sea turtles.

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Rosemary Island Hawksbill Turtle Tagging Program

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Rosemary Island in the Dampier Archipelago supports globally significant hawksbill turtle nesting beaches. The Rosemary Island marine turtle tagging program is a primary capture-recapture study of hawksbill turtles during their peak nesting period (October). Low numbers of green and flatback turtles are also tagged during the two week census. The program is one of the longest ongoing studies of marine turtles in Western Australia with the first turtles tagged on Rosemary Island in the 1985–86 turtle nesting season. The program was formally established in 1993 and tagging of hawksbill, green and flatback turtles was conducted on an *ad hoc* basis throughout the summer months. Since the 2003–04 turtle nesting season the program has focused on hawksbill turtles and has involved a targeted two week tagging program in October using index beaches. The program is run by the Department of Environment and Conservation's (DEC) Marine Science Program and the field component is delivered by DEC's Pilbara Region. All tagging data (including tag recoveries) from this program are held in the DEC Western Australian Marine Turtle Research and Monitoring (WAMTRAM) database. Data from this program are yet to be analysed. Funding for data analysis has recently become available so data will be analysed in the near future.

Understanding the Early Offshore Migration Patterns of Turtle Hatchlings and the Effects of Anthropogenic Light: a Pilot Study Using Acoustic Tracking

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We report the results of a pilot study on in-water movement of flatback turtle (*Natator depressus*) hatchlings conducted at Eco-Beach (Lat 18°19.767'S, Long 122°04.939'E), WA, January 2012. Our study tested the effectiveness of acoustic tracking technology as a means of quantifying turtle hatchling movement and for the influence of artificial lighting on turtle hatchling in-water movement. New advances in technology have overcome the main issue hindering acoustic tracking of turtle hatchlings – the size of transmitters. Transmitters used in our study were only 0.4 g, approximately 1 % of the body mass of the hatchlings and did not appear to impede either swimming or buoyancy of the turtles to which they were attached. Acoustic tracking is routinely used to monitor fish movements, but this study is the first one to apply this technology to turtle hatchlings. We used both manual and automated acoustic tracking technology. Automated tracking consisted of an array of 18 monitoring receivers set up in the surf zone to detect signals from miniature, acoustic coded transmitters attached to 26 turtle hatchlings released into the array. We released hatchlings into the array either in the presence, or in the absence, of artificial lighting. We also fitted three turtle hatchlings with coded acoustic transmitters and then followed them in a small boat using a mobile acoustic receiver with directional hydrophone. Of the 26 individuals tagged and released in the study area, 22 were recorded by our tracking array. Turtles largely travelled against the direction of wave propagation, regardless of the artificial light sources, however, our experimental design precluded conclusive testing of whether artificial light has effects on in-water movement beyond the surf zone. Using the mobile acoustic receiver, we were able to track turtles 1–2 km from shore. Our pilot study highlights the potential for acoustic tracking as an effective tool for monitoring the in-water movements of newly-hatched turtles and is particularly useful for addressing questions related to the effect of light on navigation by turtle hatchlings. Careful consideration must be given to experiment siting and timing and conservative distances between receivers are required for successful animal positioning. Data provided by the technique will be essential for the appropriate planning of new industrial developments and in particular management of the type and positioning of lights in relation to turtle nesting beaches.

Sea Turtle Conservation Medicine

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Conservation medicine is the investigation of health and disease in relation to ecosystems. People working in conservation fields are developing a growing understanding of the potential impact of wildlife disease on biodiversity and the importance of wildlife health in determining ecosystem health.

Zoo veterinary teams can make a valuable contribution to conservation programs by bringing a conservation medicine focus to collaborative projects. Perth Zoo veterinary staff have skills in sea turtle management and evaluation, as well as established credentials in cooperating in conservation medicine programs in WA. Ways in which veterinary staff could enhance existing programs include:

- providing veterinary advice and support to rehabilitation efforts
- conducting veterinary examinations and investigations of sick or injured sea turtles
- providing protocols, advice and direction for the collection and analysis of biological samples from living and dead sea turtles
- providing epidemiological interpretation and feedback on biological and health data collected from sea turtles

Although Perth Zoo does not have specific funding allocated for conducting prolonged wildlife investigations, veterinarians are happy to advise on health aspects of existing programs. Perth Zoo is also open to discussion and development of co-funded partnerships in conservation programs with a veterinary focus.

Genetic Affiliations and Key Habitats of Marine Turtles in the Kimberley Region, Western Australia

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Introduction

Despite the lack of published data on marine turtle populations in northern Western Australia, the region has been known to support some of the largest nesting populations in the world. Population estimates have mostly been based on available information in Gascoyne and Pilbara regions of Western Australia. Due to its remoteness, little dedicated research had been undertaken in the Kimberley region until INPEX Browse Pty Ltd proposed to develop a LNG plant on the Maret Islands (Bonaparte Archipelago), which was relocated to Darwin in 2009; and Woodside Energy Limited proposed to develop at James Price Point (Dampier Peninsula) (Figure 1). As part of the environmental approvals process, INPEX (2006–07) and Woodside (2009–current) engaged RPS to conduct a suite of ecological studies to identify rookeries, mating aggregations, inter-nesting and post-nesting movements and foraging areas that are linked to these rookeries. This paper presents some of the key findings of these baseline studies including genetic sampling, aerial surveys that covered all mainland and island beaches between Broome and Truscott, and satellite tagging of green and flatback turtles.

This paper also highlights that although Management Units should be defined by mitochondrial markers or the maternal linkages between rookeries, they should also recognise the linkages between nesting and foraging ground. Impacts occurring at a foraging area, in which turtles spend the majority of their lives, will affect our ability to predict what happens at nesting beaches and should therefore be considered in the management of nesting breeding populations.

Figure 1. Location map of the Kimberley region study sites

Results

Genetic Affiliations- Green turtles

A total of 42 tissue samples from green turtles were collected to conduct mitochondrial DNA analysis. Haplotype frequencies analysed at the Maret Islands were compared with the Lacepede Islands, Exmouth, Scott Reef and Ashmore Reef. The results indicated that the green turtles of the Bonaparte Archipelago were part of the Northwest Shelf Management Unit (NWS) and distinct from the offshore units at Scott Reef and Ashmore, despite their relative closeness (Figure 1). The NWS is aptly named given the genetic population remains within the continental shelf. The haplotype tree also indicates that the NWS is indirectly affiliated with the Gulf of Carpentaria (Figures 2 & 3). It is thought that rookeries in the Gulf of Carpentaria were colonised by individuals from the Northwest Shelf after sea levels rose around 10,000 years ago (Dethmers et al. 2001). It is already known that some Northwest Shelf turtles feed in the Gulf of Carpentaria and the pattern from the present study is consistent with the notion that there is a continuous unit occupying the continental shelf in the north of Australia.

Genetic Affiliations- Flatback turtles

A total of 26 tissue samples from flatback turtles were collected to conduct mitochondrial DNA analysis. Haplotype frequencies analysed at the Maret Islands were compared with Cape Domett, Barrow Island, Cape Thouin and the Dampier Archipelago. Tests of genetic divergence reveal that there are no significant differences between the Barrow Island and Dampier Archipelago/ Cape Thouin rookeries. However, significant genetic divergence among the remaining rookeries indicates limited gene flow among these rookeries and designation of three populations that encompass the Cape Domett, Maret Island and the Northwest Shelf Management Units. Further samples have been collected but have yet been analysed. Olive Ridley haplotypes were also detected in one sample suggesting possible hybridisation (male flatback; female olive ridley.

Key Nesting Habitats

Aerial surveys of turtle tracks were conducted over three consecutive days in late January 2007, providing a snapshot of the nesting distribution in the Kimberley. The survey covered approximately 1600 km, which included 180 km of sandy beach. A total of 1157 fresh tracks were recorded at optimal tide and captured on digital video. The main rookeries identified were the Lacepede Islands (60%) and the Maret Islands (20%) (Figure 4). Other

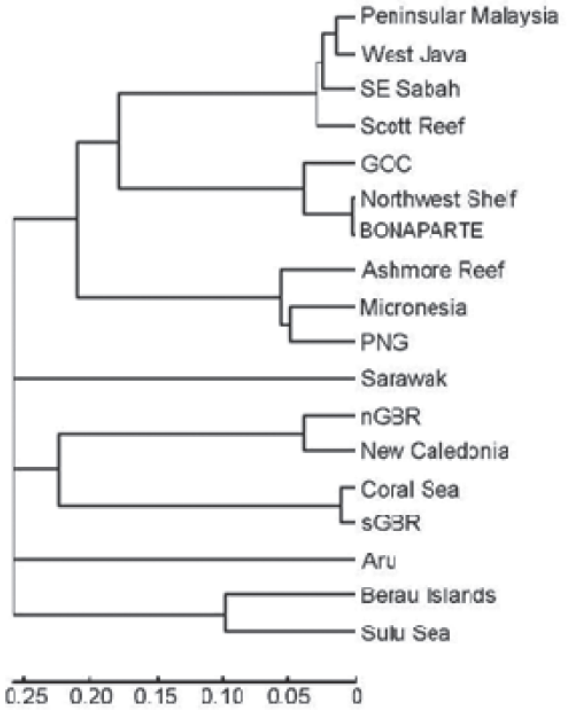

Figure 2. Haplotype tree for green turtles in the Indo-Pacific Region (RPS 2008). From: RPS 2008. INPEX Environmental Impact Studies: Marine Turtle Studies. Prepared for INPEX Browse Ltd, Perth. May 2008.

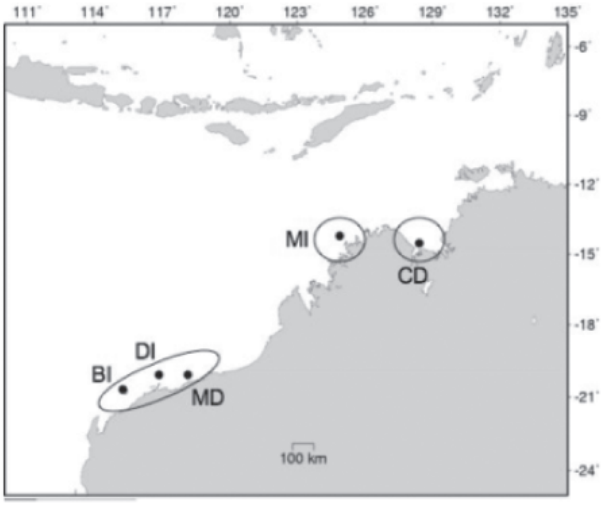

Figure 3. Genetic divergence among the Indo-Pacific Region flatback turtle groups sampled in Western Australia (RPS 2009). From: RPS 2009. INPEX Environmental Assessment Studies – Supplementary Report: Marine Turtle Studies 2007–08. Prepared for INPEX Browse Ltd, Perth. February 2009.

studies have identified the Lacepede Islands as one of the major green turtle rookeries in Western Australia. Minor nesting areas (50–70 tracks) included Cassini Island, Montalivet Islands and Lamarck Islands, while low numbers (<10 tracks) were recorded at Coronation Islands, Haywood Islands and Hat Point. Nesting activity

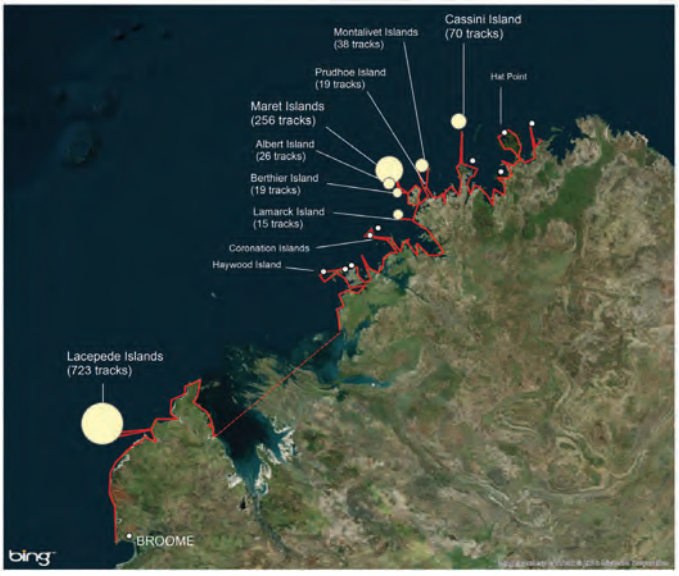

Figure 4. Kimberley region turtle nesting areas aerial survey late January 2007. Key – Symbol sizes denote relative abundance of tracks – the smallest circles are <10 tracks. The red solid line represents the flight path. Data are the number of new tracks by site for a single day.

was reduced closer to the mainland, which was also found in the Northern Territory (Chatto 1998). Mainland beaches supported very low nesting densities, mainly due to unsuitable nesting environment such as rocky outcrops, unstable dune systems, muddy substrates, mangrove forests and narrow beaches susceptible to flooding during spring tides.

Satellite Telemetry

A total of 22 Fastloc tags (11 green, 11 flatback) were deployed from the Lacepede Islands during the 2009/10 nesting season. Location and time data were obtained from Argos Satellite System. The transmitter duty cycle was continuous for 3 months, then every third day. Both ARGOS and GPS data were filtered: GPS locations ?6 satellites (95% confidence of 70 m); ARGOS Location Class 3, 2 and 1 only (estimated error <1500 m); and travel speed (<5 km/h), bearing (<25°).

Inter-nesting

The results indicated that green turtles remained within 20 km and spent the majority of the inter-nesting period within 5 km and in <20m of water. In contrast, flatback turtles showed a broad spatial distribution compared with other Cheloniids, with a maximum distance of 60 km from the islands. Individual flatback turtles displayed extensive 'looping' behaviour between nesting events.

Migration

Green turtles that migrated north-east from the Lacepede Islands remained within about 50 km of the WA coast during their migration. Once green turtles reach the Joseph Bonaparte Gulf they moved off the coastline, travelling directly across the Gulf to either the north or south of the Tiwi Islands. Two turtles travelled south and

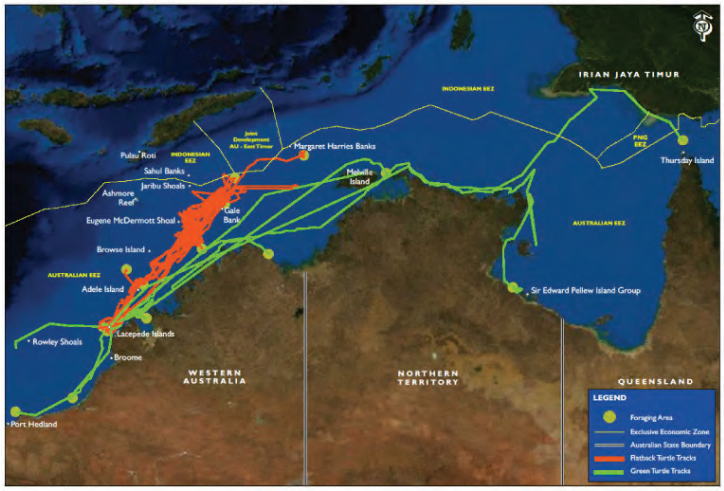

Figure 5. Migration pathways of green and flatback turtles in the Kimberley region

one travelled west to Rowley Shoals (Figure 5). Foraging areas are generally coastal where benthic primary producer habitat is present. The maximum straight line distance was 2,400 km. Flatback turtle migration paths were between 60 and 130 km from the WA coast. Seven flatback turtles went to the Holothuria Foraging Ground (HFG) (Figure 6), one went just beyond HFG and two remained near the Lacepede Islands. This appears characteristic of flatback migration pathways from southern WA rookeries, with the majority of turtles heading to HFG. The maximum straight line distance was 1,000 km.

Foraging Grounds

The HFG covers 25 000 km^2 (100km x 250km), with flatback turtles moving between Gale Banks and Eugene McDermott Shoal. They remained within 40–70m depths. Prawn trawling vessels in eastern Australia have indicated that the majority of flatbacks are captured in turbid and shallow nearshore waters. However, this is not the case in the Kimberley region. Studies from Ningaloo also show loggerhead turtles travel to HFG. If 7 of the 11 flatback turtles in this study utilise this area and we know other studies show similar results (see seaturtle.com), we are looking at large densities of flatback turtles in this particular foraging ground.

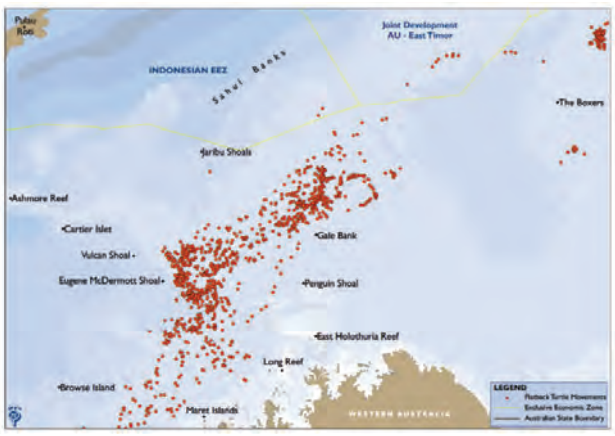

Figure 6. Area covered in the HFG

Conclusion

The key points from this paper are that the green turtle MU needs to be reviewed to include those in the Kimberley region as far as the Bonaparte Archipelago. Flatback turtles in the Kimberley region should be considered a separate genetic population until we can confirm their genetic affiliations and additional samples are analysed.

Aerial surveys indicated that the Lacepede Islands makes up 60% of the Kimberley population and the Maret Islands 20%, with the Bonaparte Archipelago supporting a significant nesting population of green turtles in the north Kimberley region.

Flatback turtles show a narrow migration pathway across the Kimberley region, while green turtles appear to have a broader migration distribution with numerous potential foraging areas. The Holothuria Foraging Ground has now been identified as an important foraging area for flatback turtles in WA and foraging habitats for flatback turtles are not restricted to inshore shallow turbid waters.

Both species travel through State and International boundaries requiring collaborative management.

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RPS Environment, Woodside Energy Limited, INPEX Browse, TUCF, Pearl Seas Charter, Kimberley Land Council Fieldwork assistance: Leanne Smith, Martin Buck, Rachel Strom, Pip Tompson, Kris Holmes, Josh Regan, Jeff Parriman, Gordon Dixon.

Identifying Trends in Turtle Populations Showing Consequences from Different Monitoring Regimes

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Estimating abundance and assessing trends is often a fundamental goal when monitoring threatened species so that conservation measures can be adopted to minimise or halt decline in population numbers. Detecting trends in sea turtle populations often requires many years of monitoring due to iteroparous nature of sea turtles where they often skip years between breeding and environmental stochasticity causing differing capacities for breeding. This causes differing availability of animals to capture and high inter-annual variability in nesting abundance. This presentation explores the number of years required to detect different rates of population change for green, loggerhead, hawksbill, flatback and leatherback turtles, with reference to the power and significance level of detection. We show the consequence of error in abundance estimates from different monitoring regimes on the time needed and confidence to detect trends in populations, specifically showing annual errors of ±50% leading to a 10–14 year increase in the number of years needed to detect a 3% decline in the population with power= 0.9 and confidence= 0.05. This presentation shows that the number of years to effectively detect trends in populations can be significantly reduced for green turtles by reducing the coefficient of variation of the time-series using biological and climatic predictors, most notably the Southern Oscillation Index and specific humidity. This presentation also explores other potential early indicators of population change such as threshold limits that don't rely on traditional line fitting approaches. The underpinning models were developed using data collated from populations worldwide. This presentation uses two Western Australian turtle populations, at Cape Domett and Ningaloo, as case studies for detecting long-term trends.

High Density Flatback Turtle Nesting at a Winter Rookery

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Surveys to the flatback turtle, *Natator depressus*, rookery at Cape Domett, located in the north-east Kimberley, were undertaken during 2006, 2007, 2009 and 2010. Track counts were used to estimate annual abundance and confirmed Cape Domett as a significant flatback turtle rookery with an estimated 1900–3250 turtles nesting each year. Satellite transmitters were attached to five flatback turtles which revealed migration pathways to inshore waters of the Northern Territory and offshore to the Timor and Arafura Seas. Between nesting activity, flatback turtles moved around the Joseph Bonaparte Gulf adjacent to Cape Domett. Nesting success and hatching (incubation) success was assessed and predation of eggs, hatchling and adult turtles noted. Collaborating scientists, DEC staff, volunteers, indigenous Rangers and Traditional Owners participated in field trips.

The North West Shelf Flatback Turtle Conservation Program (NWSFTCP)

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Australia-wide environmental offsets are becoming increasingly common as a tool for environmental management and are used as a last resort after avoidance and mitigation measures. The Commonwealth and most States and Territories have policies, guidelines or position statements on the identification and implementation of environmental offsets (for examples see Environmental Protection Agency (Qld) – 2008, DSEWPaC 2011). In Western Australia, environmental offsets are outlined in a position statement (Environmental Protection Authority – WA 2006), guidance document (Environmental Protection Authority – WA 2008) and policy (Anon. 2011).

The North West Shelf Flatback Turtle Conservation Program (NWSFTCP) is one of four environmental offsets from the Gorgon Gas Project at Barrow Island and is outlined in the Variation Agreement 2009 to the Barrow Island Act 2003 (http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_76_currencies.html). The purpose of this offset is to increase the conservation and protection of the Northwest Shelf flatback turtle population including: (a) surveying, monitoring and research; (b) reducing interference to key breeding and feeding locations; and (c) establishing information and education programs. The North West Shelf flatback turtle population is defined as the summer breeding management unit (MU) that nests from the Pilbara to the south west Kimberley. Under this definition, this not only includes the conservation at nesting beaches and WA waters but includes the whole range and life history of this MU (including Commonwealth, Northern Territory and Queensland jurisdictions). A total of $32.5 million has been allocated to the offset program over 30 years at which time a review by the CALM Act Minister will assess the program and decide whether an additional $30 million dollars for a further 30 years is necessary. To advise the Director General of the Department of Environment and Conservation an Advisory Committee will be established that will include an independent Chair and a member from the Joint Venturers, Department of Environment and Conservation (DEC) and the Commonwealth government (Department of Sustainability, Environment, Water, Population and Communities). In addition, a Scientific Panel of Experts will be formed to support the Advisory Committee with technical advice. The NWSFTCP will form part of sea turtle conservation strategy for Western Australian.

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It Starts with One: Delineation of Foraging and Mating Habitats Used by a Flatback Turtle in Western Australia

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A MK10-A (Wildlife Computers) satellite transmitter was deployed on a nesting flatback turtle at Cemetery Beach, Port Hedland in 2009/10. The transmitter recorded Argos quality location data in addition to recording a dive point every two seconds at a 0.5 m depth resolution. The turtle returned to Cemetery Beach during the 2010/11 season to nest, enabling the unit (which was still operating) to be recovered. The transmitter had recorded the location and dive depths for the entire duration of the turtle's initial inter-nesting phase, post-nesting phase (including its migration to and from its foraging habitat and the time spent within its foraging habitat) and its subsequent mating phase prior to nesting.

Foraging and mating behaviour was inferred from periods of time where the displacement distance from the turtles post-nesting migration departure location neither increased nor decreased. Dive data was further categorised according to the defined behaviour at the time the dive was recorded.

Displacement data identified the turtles main foraging habitat was located approximately 13 km to the west of Thevenard Island and the mating habitat approximately 33 km to the north-east of Port Hedland, 7 km from the mainland. The seabed depth for each transmitted position recorded within the mating habitat ranged from 0.2 – 4.2 m (n = 15). The turtle remained within its foraging habitat for 246 days, within the mating habitat for 21 days and after leaving the mating habitat, nested on Cemetery Beach 3.5 days later. The overall remigration interval was 324 days.

When the turtle was foraging, it recorded an average of 1.2 dives per hour, with each dive point at an average depth of 50.2 ± 22.7 m (range = 0 – 102.5, n = 10,649,589). When the turtle was mating, it recorded an average of 4.7 dives per hour, with each dive point at an average depth of 6.3 ± 2.7 m (range = 0 – 16.5, n = 733,841).

This recovered transmitter provides an insight into the behaviour of the flatback turtle within its foraging habitat and, for the first time in Western Australia, within the mating habitat. Identifying the location of mating grounds for flatback turtles is important as these areas can host a dense aggregation of both adult female and male flatback turtles and enables effective conservation and management planning of these areas from potential threats.

Delineation of the Temperature-dependent Sex Determination (TSD) Parameters of Loggerhead Turtles in WA

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For the first time, temperature-dependent sex determination (TSD) parameters were delineated for the genetically distinct Western Australian (WA) loggerhead (*Caretta caretta*) population by experimentally manipulating the thermal conditions during embryonic development. Loggerhead sea turtles lack sex chromosomes, and instead exhibit a type 1A TSD where high incubation temperatures produce females and low temperatures produce males. This study found that WA loggerhead turtles had a pivotal temperature of 29°C and a 1.05°C range where both sexes are produced. The thermosensitive period determined from back-switch experiments was between 32–62% of development. These parameters were similar to those estimated for other loggerhead populations, suggesting that sex determination thresholds are highly conserved between populations worldwide.

Poster Presentations

Guys, girls and global warming – predicting hatchling sex ratios of the Flatback turtle (*Natator depressus*) in Western Australia now and in the future

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Population sex ratio is a vital demographic parameter for assessing the viability of threatened species. The sex ratio of species with temperature-dependant sex determination (TSD) depends upon temperatures experienced during incubation, which vary temporally and spatially.

We used a mechanistic model to predict sand temperatures and empirical data to predict corresponding hatchling sex ratios in the Flatback turtle (*Natator depressus*) along the western Australian coastline. As most physiological data on *N. depressus* has been collected from East Coast populations, we measured sex ratios under laboratory and field incubation to produce a sex determination function for the genetically distinct West Coast *N. depressus* population. Predicted sand temperatures were compared with nest temperatures measured in the field and were a good representation of average beach temperatures, but did not account for fine-scale variation in aspect, shade, sand density, reflectance and thermal conductivity. Sex ratios were predicted at three representative nest depths (400–600mm) and during five potential laying months (October–February) under the current climate.

Eggs laid in October produced mainly males or male biased nests with the exception of Cape Domett in the far north of Western Australia. In later months a higher proportion of mixed sex nests appeared in lower latitudes around the Dampier Archipelago, while a higher proportion of males were predicted along the Kimberley coastline. The effects of climate change on sex ratios in 2030 and 2070 under high and low emission scenarios were also examined, and an increased proportion of female biased nests were predicted. Laying earlier in the nesting season and at latitudes south of Exmouth, would appear to be the most effective behavioural adaptations for neutralising the female-biased sex ratios predicted under global warming.

Barrow Island Offshore Light Spill Survey: An Investigation into the Relationship between Artificial Light Spill Over Water and Hatchling Congregation

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The Hatchling and Offshore Vessel Light Survey has been designed to assess whether marine turtle hatchlings, during offshore migration from nesting beaches on the east coast of Barrow Island, are influenced by artificial light sources on construction vessels and the Materials Offloading Facility (MOF) associated with the Gorgon Gas Development. In particular, it was important to understand what factors may be influencing their dispersal in terms of hatchling congregation around light spill, degree of attraction to light sources and type of light source.

A total of 29 hatchlings were observed during 29 nights of survey, with all hatchlings observed during February 2012. Of the hatchlings observed, 21 were flatback (*Natator depressus*) hatchlings, six were green turtle (*Chelonia mydas*) hatchlings and two were unidentified. Predatory species of teleost, cephalopod and shark were frequently observed at survey sites; however, no evidence of predation was documented.

The results of statistical analysis on an array of environmental factors incorporating lunar phase, tidal state, wind direction and observed hatchling numbers yielded no significant associations ($p > 0.05$). Results from a GAM regression model comparing hatchling emergence figures on nearby beaches and observed hatchling numbers offshore concluded that no significant relationship existed. While good light management practices may be reducing the attraction of hatchlings to the MOF, there is evidence elsewhere that the primary cue for hatchlings during their swim frenzy is wave direction and may override any influence of artificial light during this frenzied swimming stage.

All hatchlings observed within light pools were illuminated by 1000 W High Pressure Sodium (HPS) bulbs (x4) on mobile floodlight towers. There was no significant difference in the number of hatchlings attracted to areas of light spill compared to areas with no light spill ($p > 0.05$).

Notwithstanding the limitations of this survey, few hatchlings were observed in light spill around the MOF relative to known emergences. The absence of observed hatchlings may reflect directional swimming into wave fronts, with this behaviour overriding attraction to lights. Attraction to light sources may be associated either with passive (coincidental) dispersal dictated by wave refraction from the MOF and the flow of currents in this area, or active attraction (directional swimming) to a light source.

A Case Study of the Commercial Marine Turtle Fishery in Western Australia, 1869 – 1973

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Anecdotal evidence of the abundance of marine turtles in Western Australian waters was documented by European explorers from the early 1800s. Many attempts were made to exploit both the green and hawksbill turtle commercially from the mid-1800s. The first commercial export of hawksbill tortoiseshell appeared in the Western Australian trade tables in 1869 and the green turtle fishing industry operated intermittently between 1870 and 1961 prior to the industry becoming successfully established in the 1960s. Historical evidence suggests that up to 55,125 (archival records) and 69,000 (oral histories) green turtles were potentially harvested from Western Australian waters prior to the industry being closed down in 1973. Upper estimates indicate that 20,445 hawksbill turtles were harvested from northern Western Australia over the course of 84 years. It is argued that the exploitation of green turtles led to an observable decline in the numbers of these animals and it is likely that the fishing effort for the tortoise shell industry had an adverse impact on hawksbill turtle populations in the State's north-west. In a global context, the exploitation of the green and hawksbill turtles in Western Australia occurred at a time when there was an extensive international harvest of marine turtles. The relatively small-scale harvest that took place in Western Australia is likely to have been a factor contributing to the green and hawksbill populations of Western Australia being some of the largest populations remaining in the world. This research provides a detailed historical account of the commercial exploitation of marine turtles in Western Australia, including empirical accounts of the total number of animals harvested from turtle populations throughout the State.

Mitigation of Turtle Captures in Western Australian Prawn and Scallop Trawl Fisheries

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Prawn and scallop trawl fisheries in Western Australia (WA) are valued at AUD 50–60 million annually and provide employment for over 500 crew and additional support and processing staff in Perth and regional communities. In recent years, about 70 boats have operated in defined managed fisheries around the state with much of the coastline being closed to trawling or unfished (Fig. 1). Historically reports of turtle encounters by trawl nets have been infrequent with the majority of those turtles captured being returned to the sea alive.

In December 1998, the Australian Standing Committee on Fisheries and Agriculture finalised the National Policy on Fisheries Bycatch. The Policy was developed to provide a national framework for coordinating action to address bycatch issues. In June 1999, the WA Government adopted this national policy and developed a framework for the implementation of bycatch reduction devices into trawl fisheries (Bunting 2002).

At the same time, the *Environment Protection and Biodiversity Conservation Act* 1999 (*EPBC* Act) was

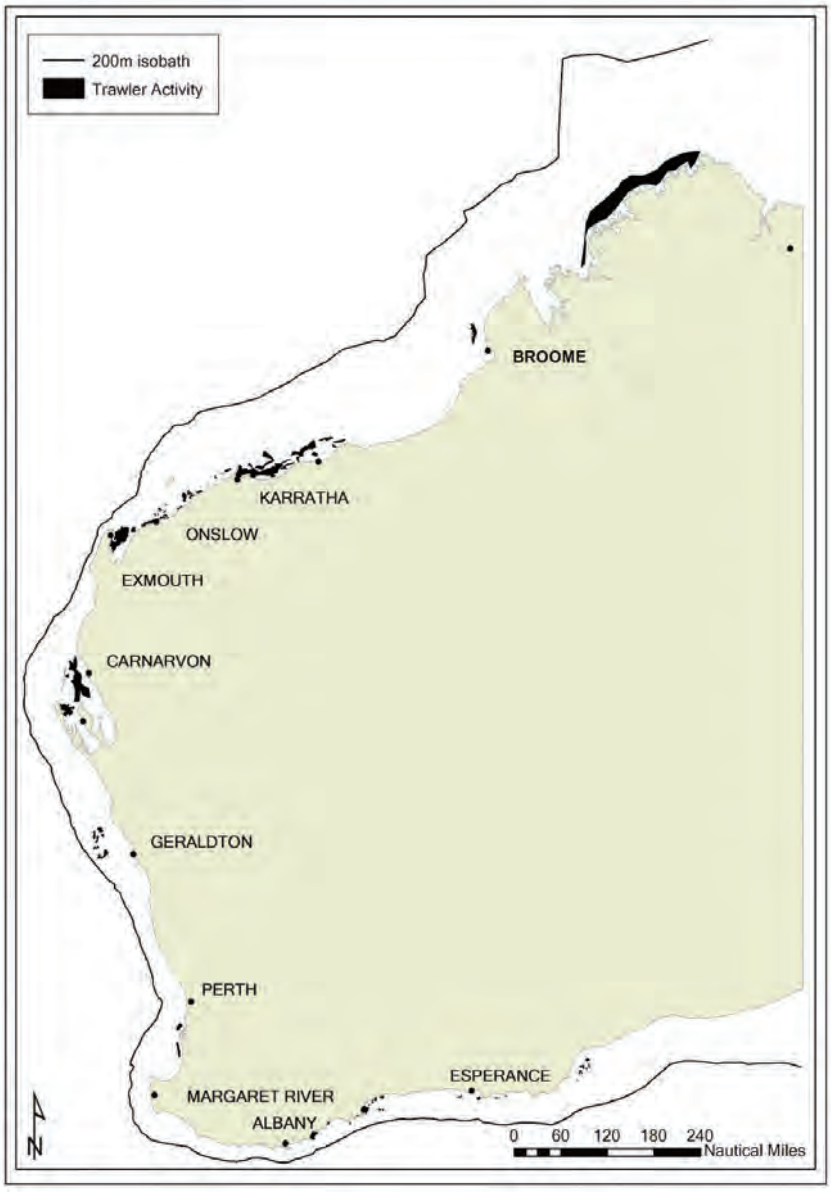

Figure 1. Prawn and scallop trawl areas in Western Australia within the 200m isobath (extent of fishery boundaries).

developed by the Commonwealth Government. As a consequence, the incidental capture of protected species (including turtles) in Commonwealth waters became an offence. An exemption to this offence is that boats operate in accordance with management arrangements accredited by Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), which include incorporation of bycatch reduction devices (BRDs) in trawl nets to reduce catch of turtles as well as the volume of overall bycatch. The compulsory installation of BRDs, in particular grids (otherwise called TEDS or turtle exclusion devices) has been a requirement in all prawn and scallop trawl fisheries in WA since 2002/03. These devices significantly reduce the take of large animals including sharks, rays, turtles and sponges.

The BRD implementation program in WA 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 Thomson 2004). This led to legislating minimum standards whilst still allowing innovation and experimentation by industry. A phased approach was adopted, with BRDs being tested in half of the trawl gear initially to allow for the assessment of their impact on bycatch as well as target species catch and for the calibration for different areas and times of year before BRDs were required to be installed in all main trawl nets.

The key benefits of BRD implementation is a 95–100% reduction in the landings of larger sharks, rays and turtles and the potential reduction in bycatch (smaller fish and invertebrate species) of 20–40% with only a low reduction (5–7%) of target species catches. In addition, the quality of retained product has improved due to less damage from large animals and reduced sorting time and hazards of handling large, heavy and sometimes dangerous animals.

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Cable Beach Community-based Sea Turtle Monitoring Program: The First Six Years

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Introduction

This poster presentation follows the creation, development and successful implementation of Broome's first and only annual sea turtle monitoring program. With Australian flatback *(Natator depressus)* sea turtles of the Northwest coast of Western Australia as the focus species, thousands of hours monitoring Cable Beach by community volunteers has taken place over the first six years of the program. The Marine Species division of not-for-profit Conservation Volunteers Australia delivers annual sea turtle programs and has been involved in sea turtle research and conservation in Western Australia since 2005. Despite not having as high a nesting density of flatback turtles as Cape Domett, Barrow Island, the Pilbara region or even Eco Beach (25 nautical miles south of Cable Beach), nesting activity on Cable Beach is of interest because:

- The 6km survey area is part of a much larger beach 16km long
- Human development occurs adjacent to sectors of the beach
- The survey area experiences high tides in excess of 10m
- It is a very public beach where camels and a range of vehicles are permitted

The Cable Beach Community-based Monitoring Program came into existence early 2005 with local negotiations to gauge the level of interest in sea turtles nesting around Broome. Following staff training at similar track and nest count programs further south at Port Hedland and Ningaloo, the first year of Cable Beach monitoring commenced on the 1st November 2006 and volunteers have each year since walked a 6km section of the beach for 120 days.

Methods

This Conservation Volunteers Australia program engaged members of the Broome community and visitors to the region to undertake morning track and nest counts for flatback turtles from the 1st November to the 28th February annually.

The program aims are to:

- Collect annual data on the number and state of sea turtle nests on a 6km section of Cable Beach.
- Assess long term annual nesting data so that informed management decisions can be made regarding the protection of sea turtles and their habitats.
- Inform and educate local community members and visitors about the presence of nesting turtles through volunteer training, public presentations and media representations.

Extensive volunteer training is given in Broome prior to the commencement of monitoring with ongoing support throughout the season. Topics covered in the training sessions include a glossary of terms, types of monitoring projects, threats sea turtles face, species guide, status/

Figure 1. Cable Beach sectors

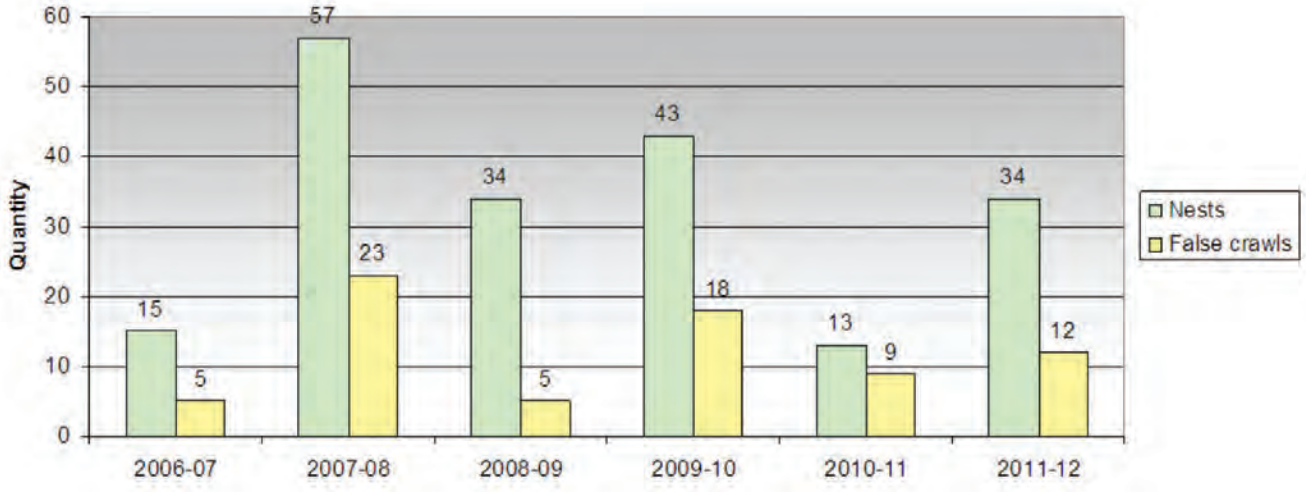

Figure 2. Annual nesting activity

		2006	2007	2008	2009	2010	2011
Total distance of the survey area		6km	6km	6km	6km	6km	6km
Total number of records (nests and false crawls)		20	80	39	61	22	46
Number of nests		15	57	34	43	13	34
Number of false crawls		5	23	5	18	9	12
Nesting activity by other species		3 (green turtle)	0	0	0	0	0
Nests:	Sector 1	1 *	27	18	10	6	4
	Sector 2	4	17	13	23	7	27
	Sector 3	10	13	3	10	0	3
False crawls:	Sector 1	0	9	0	7	6	5
	Sector 2	2	11	3	7	2	3
	Sector 3	3	3	2	4	1	4
Average adult track width		NR	NR	NR	92cm	94cm	97cm
Body pits per nesting attempt:							
	Average	NR	NR	NR	1.4	1.2	1.6
	Minimum				0	5	0
	Maximum				0	3	3
Most favoured nesting area on the beach		Edge of vegetation to the dune	Edge of vegetation to the dune	Edge of vegetation to the dune	Edge of vegetation to the dune	Edge of vegetation to the dune	Edge of vegetation to the dune
Number of predated nests		NR	NR	NR	5	1	7
Known hatchlings per sector:							
	Sector 1	NR	NR	NR	305	233	75
	Sector 2				238	101	80
	Sector 3				94	132	0
Average hatchling track width		NR	NR	NR	91mm	87mm	70mm
Average incubation period		NR	NR	NR	50 days	47 days	48 days
Main nesting period		2nd to 28th Dec	24th Nov to 17th Dec	20th Nov to 11th Dec	4th to 22nd Nov	19th Nov to 5th Dec	28th Nov to 24th Dec

Figure 3. Additional annual data results, NR=Not Recorded

licensing/handling protocols, safety on the beach, stranded wildlife, data sheet explanation, nest versus false crawl determination and hatchling emergence.

Patrols are conducted each day of the nesting season from sunrise to 9am with volunteers walking their rostered 2km sector (Figure 1). Support to the patrols is given by Conservation Volunteers Australia Broome office staff and Chelonia Wildlife Rehabilitation & Release, which accepts any stranded wildlife found.

Results

The flatback sea turtle is the prime nesting species at Cable Beach and hence the focus of the program; however, green turtles *(Chelonia mydas)* have also visited Cable Beach with one nest and false crawl recorded during the 2006–07 season. Other species such as hawksbill *(Eretmochelys imbricata),* loggerhead *(Caretta caretta)* and olive ridley turtles *(Lepidochelys olivacea)* are also known to inhabit these waters.

Nesting activity has been collated for five of the last six years at the same sectors of Cable Beach. An initial sector preceding the current Sector 1 was dropped after the 2006–07 season due to minimal activity and replaced with Sector 3. The same turtles do not generally nest each year, although many flatbacks at nearby Eco Beach do; however, as this is not a tag and recapture program it should be assumed that most are on a two to four year cycle. Nest and false crawl activity (Figure 2) for the first six years of monitoring indicates no real trend of remigrants and their nesting cycles.

The training of volunteers, the data sheets and the level of information recorded increased from 2009 onwards such that trends to date for some data, for example the level of nest predation, are not possible. Some factors have remained constant (Figure 3) such as the turtles favouring the section of beach from the edge of the vegetation to the dune for nesting. The nesting peak at Cable Beach appears to be from late November to mid December with the first hatchling emergence normally around Christmas Day.

Participation levels on the program over the first six years has been very strong with an average of 635 hours per season in the last three years spent monitoring the beach. The program attracts annually between 80 and 110 individual volunteers (locals and visitors) walking their rostered sector before commencing their daily work commitments in most cases.

Conclusions

Conservation Volunteers commenced the Cable Beach Community-based Sea Turtle Monitoring Program in November of 2006 to answer the following questions:

- What type of turtles nest on Cable Beach?
- When and how often?
- Can the local community be trained to conduct daily monitoring for four months of the nesting season?

Six years on and the program has succeeded in obtaining answers to these questions, considering tag and recapture of turtles for a population count is not an action of this program. More years of data are required to make precise statistical observation of Cable Beach nesting trends as to whether the number of nests have increased, declined or remain constant.

The flatback sea turtle is listed internationally as Data Deficient (IUCN Red List of Threatened Species). Flatbacks in Western Australia are listed as Vulnerable. The Cable Beach Community-based Monitoring Program, managed by Conservation Volunteers, is a Wild Futures initiative. Wild Futures is working to protect key species and their habitats including flatbacks in this West Kimberley region. Annual data from this program, together with data from monitoring at nearby Eco Beach, allows for a greater understanding of flatback nesting populations in and around the Roebuck Bay area of Western Australia.

Marine Turtles and the Fossil Fuel Frenzy

Oil and Gas Operations, Spills and Expansion – A Threat to Conservation

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Oil and gas facilities are known to disturb, injure and kill marine turtles while also degrading marine and coastal habitat critical to their survival and recovery throughout the entire scope of activities from exploration to decommissioning, including oil spills. The oil and gas industry is expanding offshore and into areas of high marine biodiversity where in some cases long-term scientific baseline assessments have never been completed. Conservationists are concerned that environmental reviews of oil and gas projects, when conducted, fail to adequately consider or prevent harm to marine turtles and marine species. The cumulative impacts of multiple developments on marine turtles and populations are regularly ignored.

Given that all seven species of marine turtles remain vulnerable to extinction, governments and oil corporations must develop and implement clear and quantifiable protective measures from fossil fuel development to prevent harm to marine turtles and destruction of marine habitat. Today, the primary avenues to safeguard marine turtles are grassroots, regulatory and legal actions. Big oil companies including BP, Chevron, Shell, Exxon-Mobile, Conoco Phillips, BHP Billiton, and Woodside Petroleum are drilling and spilling in marine turtle habitat around the world. The BP oil spill in the Gulf of Mexico, two planned liquid natural gas (LNG) facilities in the Great Barrier Reef and new and proposed LNG facilities in Western Australia, including the undeveloped Kimberley region, illustrate the problem.

BP Oil Spill Gulf of Mexico: The BP oil spill in the Gulf of Mexico was the largest environmental disaster in U.S. history and the largest accidental oil spill in world history. The well released a torrent of oil and gas into the Gulf that spewed unrelentingly for almost three months. The spill occurred during the peak of nesting season for loggerheads and critically endangered Kemp's ridley marine turtles. More than 200 million gallons of crude oil and almost 2 million gallons of toxic dispersants poisoned the waters, wetlands, and marine life.

Marine Turtle Toll: 1,200 turtles stranded or captured, more than 600 dead, 271 nests and 14,000 hatchlings displaced. Actual numbers of marine turtles lost or harmed may be 50 times more (Williams 2011). While few marine turtles were found visibly oiled, no independent wildlife observers were at sea recording marine turtles until July; over 70 days after the spill began. A large number of the unoiled marine turtles likely died in shrimp trawl nets when Turtle Excluder Device laws were not adequately enforced during the oil spill. The long-term impacts of oil exposure to marine turtles, fisheries and the environment are yet to be seen or understood.

BP Oil Spill Response and Rescue – Delays and Burning Turtles

On-water marine turtle rescue did not occur during the first 30 days after the spill.

Thousands of wildlife rescue volunteers were never allowed to assist.

Chemical oil dispersants were applied despite known toxicity to marine species.

Unknown numbers of marine turtles were harmed during in-situ burning.

Shrimp trawlers not properly using Turtle Excluder Devices during the spill contributed to marine turtle stranding spikes.

Loggerhead nests were relocated, but Kemp's ridley hatchlings were released into Gulf.

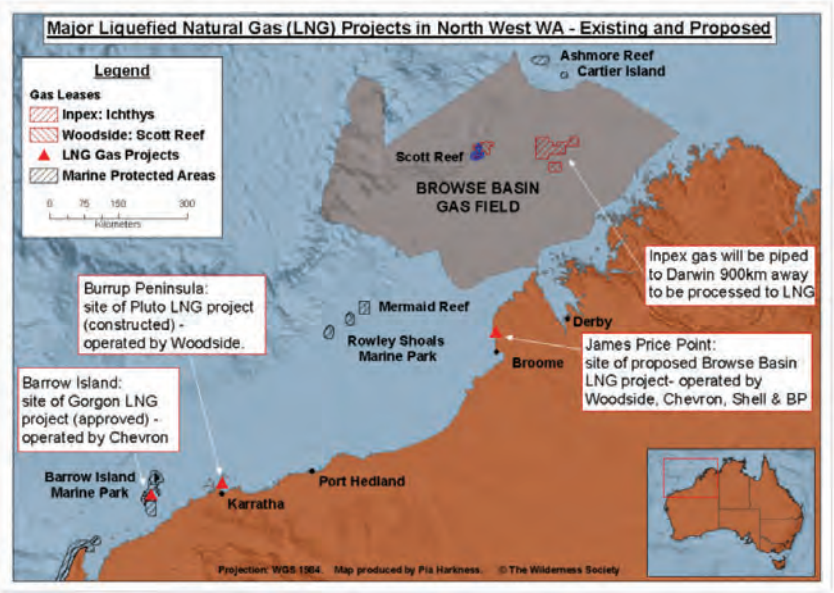
Western Australia – Kimberley Browse Basin

Woodside Petroleum Ltd., Shell, BP, Mitsubishi and BHP Billiton are pushing for the $45 billion Browse Basin LNG

Dr. Brian Stacy, NOAA veterinarian, prepares to clean an oiled Kemp's Ridley turtle. (Photo: NOAA and Georgia Department of Natural Resources).

Kemp's ridley pelagic juvenile retrieved from a grease mat in the Gulf of Mexico, June 2010. (Photo: Blair Witherington).

Fire boat response crews battle the blazing remnants of the off shore oil rig Deepwater Horizon April 21, 2010. (Photo: U.S. Coast Guard).



Map: Proposed and existing LNG projects in North West WA

Pluto LNG plant in Karratha, Western Australia (Photo: Woodside Energy Ltd).

Project in what would be the biggest gas hub in Australia at James Price Point (Walmadan) in the Kimberley, north of Broome. The spectacular coast and rich marine environment has an extraordinary diversity of wildlife with endemic species like flatback marine turtles and snubfin dolphins. Humpback whales calve along the coast. This marine environment is one of the least impacted by mankind in the world. The Kimberley region is important to endemic Australian flatbacks, loggerheads, greens, hawksbills, leatherbacks and olive ridleys. Few, if any measures protect marine turtles from oil and gas industrialization. Cumulative impacts on nesting, feeding and migratory habitat have never been considered.

Chevron Building LNG Plants On Top of Turtle Rookeries

California-based Chevron recently sold its interests in the unpopular Browse Basin project, mainly to focus on two massive LNG plants down the coast. Chevron is the major player in the Gorgon and Wheatstone projects that are sited in important marine turtle nesting and marine habitat.

Gorgon: The controversial $43 billion Gorgon LNG plant and pipeline is being constructed on a nature reserve and important marine turtle rookery at Barrow Island. Australian flatbacks that nest here then forage north in the Kimberley, where they will face major disruption if the Browse Basin proposal goes ahead.

Wheatstone: Not far from Barrow Island, Chevron is constructing the Wheatstone LNG gas processing plant with subsea pipelines connecting to gas fields 145 km offshore, through marine areas of high biodiversity.

Carbon Intensity: If the Browse Basin LNG Project goes ahead, it will be the most intensive carbon polluting LNG project in the world, emitting 0.65 tons of carbon dioxide for every ton of LNG gas produced. As intensive carbon polluters, Wheatstone will surpass Gorgon by emitting 10–15 million tons of carbon while processing 8.9 million tons of LNG per year.

LNG in the Great Barrier Reef Conservation groups recently launched a legal challenge to the U.S. Export-Import Bank's (Ex-Im Bank) nearly $3 billion in financing for two massive fossil-fuel facilities in Australia's Great Barrier Reef on Curtis Island at Gladstone in Queensland. Construction and operation of the liquefied natural gas (LNG) facilities will threaten marine turtles, dugongs, saltwater crocodiles and other protected marine species within the Great Barrier Reef World Heritage Area.

The Ex-Im Bank is a U.S. agency that funds international projects to promote U.S. exports. With these LNG projects, the Ex-Im Bank has failed to comply with mandatory environmental review under U.S. law including the Endangered Species Act (ESA) and National Environmental Protection Act (NEPA).

The Australia Pacific LNG (AUS LNG) and Queensland Curtis LNG (Queen LNG) projects will involve drilling up to 16,000 gas wells west of Brisbane, using controversial "fracking" techniques, construction of

Photo: Curtis Island LNG port development, Gladstone, Queensland. (Teri Shore – SeaTurtles.org)

hundreds of miles of gas pipelines and two massive LNG processing and export facilities on Curtis Island. The project proponents admit the construction, dredging, operation, and shipping associated with these facilities will diminish water quality, destroy habitat, and otherwise harm protected species. The AUS LNG alone will emit over 11 million tons of carbon dioxide equivalents (CO2e) per year at maximum capacity. The AUS LNG Project is a joint venture between Origin Energy, ConocoPhillips, and the China Petrochemical Corporation. The Queen LNG facility will be developed by QGC Limited, a subsidiary of the British BG Group. UNESCO, the international body charged with overseeing implementation of the World Heritage Convention, may soon list the GBR as "in Danger" due to the LNG plants and other industrial developments in the region.

Harm to Marine Turtles from Oil and Gas

Direct and indirect impacts to marine turtles and habitat are generated by construction and operations from dredging, pile driving, drilling, seismic blasting, lighting and flaring, vessel strikes, toxic discharges, trash including plastics, air pollution, water pollution, oil spills, fuel spills and noise.

Actions Need to Protect Marine Turtles from Oil and Gas

Do not site LNG plants in marine turtle nesting, feeding or migratory habitat.

Where oil and gas development occurs, drilling, expansion, refining and operations must avoid marine turtle breeding, foraging and migration habitat.

Protected marine areas for marine turtles must be established in feeding and migratory habitat where new oil and gas activities are prohibited and existing operations phased out.

New and existing oil and gas operations must be re-evaluated and modified to ensure the prevention of harm to marine turtles and avoid jeopardizing their existence.

Oil and gas corporations must be required to adopt rigorous measures to protect marine turtles from harm, adopt monitoring and reporting measures to avoid the impacts of oil and gas development, operations, oil spills and well decommissioning on marine turtles and marine life.

Marine Turtle Oil Spill Rescue and Recovery Plans

Every oil spill response and recovery plan must include specific marine turtle actions including : prioritizing endangered marine turtle rescue; providing independent observers on all oil spill response vessels; training marine turtle rescuers; developing volunteer protocol for wildlife rescue assistance workers; prioritizing nesting beaches for placement of offshore oil booms; banning chemical dispersants and "controlled burns" where endangered species are present; and full accounting of harm to and restoration of marine turtle populations and habitat immediately after a spill.

References

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Photo: Mock Chevron ad – (created by Rainforest Action Network by permission of The True Cost of Chevron Network).

Assessing the Resilience of Marine Turtle Embryos to Extreme Temperatures

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An increase in beach temperatures along the northern coast is of Australia is of concern for marine turtles and their embryos. Marine turtle embryos depend upon a narrow temperature range for optimal development and are subject to heat stress in their fixed environment within the nest. What remains unknown to scientists is the genetic capacity for embryos to tolerate and adapt to warming environments. Through novel molecular approaches, this research will investigate the thermal tolerance of marine turtle embryos by 1) measuring gene expression levels of specific heat-tolerant genes, and 2) measure the variability of those genes across several populations of *Caretta caretta* (loggerhead) and *Natator depressus* (flatback) turtles. Loggerhead and flatback turtles are of ecological and cultural importance, with flatbacks endemic only to the waters of tropical Australia. Both species are ideal candidates for study as they nest on beaches that experience variable summer temperatures from the Shark Bay to the Kimberley, and research on two species provides a comparison of the potential evolutionary responses to warm beach temperatures between a temperate (loggerhead) and tropical (flatback) species. This research will generate new and important information relevant to understanding a species capacity to adapt to climate change, and will provide data that can be used to directly assess the conservation status of *C. caretta* and *N. depressus*.

Biotic and Abiotic Factors Affecting Reproductive Success in Western Australian Loggerhead Turtles (*Caretta caretta*)

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An understanding of reproduction and nest biology is crucial for the management of sea turtle populations and hatching success is considered a critical population parameter in the Recovery Plan for Marine Turtles in Australia (Environment Australia, 2003). The purpose of this study was to collect critical baseline data regarding nest ecology and to assess several biotic and abiotic factors affecting hatching and emergence success in two important loggerhead turtle nesting beaches in Western Australia. The nesting beaches monitored were Dirk Hartog Island, the largest loggerhead turtle rookery in Australia, and the smaller mainland nesting beach located at the Bungelup beach section of Cape Range National Park.

The research was conducted for two nesting seasons (2006/07 and 2007/08). Results show that in Cape Range National Park nest predation is the main factor limiting hatching and emergence success. Nests in Cape Range National Park were predated by ghost crabs (*Ocypode* spp), monitor lizards (*Varanus giganteus*) and introduced foxes (*Vulpes vulpes*) and overall, 82.4% showed signs of partial or complete predation. In contrast, on Dirk Hartog Island the main cause of nest disturbance was flooding and beach erosion (during the second year of monitoring) and other turtles digging into existing nests.

In both locations several nests reached temperatures close to or above 33°C, which is considered the lethal temperature limit, during the last third of incubation and during the pre-emergent period (i.e. period between hatching and emergence). A negative association was found between the temperature and the hours above 33°C during the pre-emergent period and emergence success. Also, the duration of emergence (i.e. the number of nights hatchlings emerged from the same nest) was longer with higher temperatures.

Based on our results, the main identified threats for these loggerhead turtle nesting grounds are ghost crab and fox predation on the mainland, and at both sites potential increases of pre-emergent hatchling mortality and beach erosion, in the face of environmental changes associated with global warming.

Feedback from participants of the WA Sea Turtle Symposium

	Topic	1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree	participant responses
1	The symposium has provided me with new information and/or skills		2%	9%	50%	41%	46
2	The symposium has given me a greater understanding of sea turtles in Western Australia			4%	43%	52%	46
3	The workshop has given me a greater understanding of the pressures on sea turtles in Western Australia	3%	3%	35%	33%	33%	40
4	The oral presentations were interesting and useful			13%	40%	47%	45
5	The presentations were an appropriate length		3%	4%	49%	47%	45
6	The poster presentations were interesting and useful	3%	3%	25%	53%	22%	36
7	The workshops were an important component of the symposium		12%	26%	38%	35%	34
8	I felt valued, able to contribute & free to ask questions			15%	48%	37%	46
9	The information provided by the organizing committee was clear		2%	7%	59%	34%	44
10	The catering was sufficient in quality and quantity		2%	2%	36%	62%	45
11	The venue was suitable for the symposium				28%	72%	46
12	I would recommend this symposium to others				30%	70%	44

***What* aspects of the workshop were most useful?**

***Why* were they useful?**

- now have better understanding of strandings
- snapshots of turtle research
- good inclusion of indigenous, ethics, conservation medicine and citizen science
- networking with like-minded people
- learning about differences in processes regional versus corporate
- open communication in workshops
- potential collaborations
- scientific
- useful to hear specialist opinions on tagging
- some info on tag options and stranding database
- question and answer time
- community presentations
- tagging information
- presentations
- diversity of presentations
- conservation medicine and rehab talk
- discussions on monitoring standards – this helped us achieve perspective on standards

How will today's workshop help you?

- increased general knowledge that will help with management decisions relating to the Ningaloo Turtle Program
- potential collaborations across the state
- knowledge and contacts

What improvements would you suggest?

- exposure to more technical aspects of turtle monitoring
- rehabilitation discussions
- better coffee
- summary of each day/session
- talks rushed, speakers needing reminding of timing
- less presentations, longer presentations
- having a drinks/dinner session
- more structured workshops
- workshops for DEC personnel
- skills building specialist sessions
- more variety of presentations, too much overlap
- more durable name tags with affiliations
- opportunity for presenters to use computer prior to presentations
- more structured opportunity for discussion
- panel discussion
- more audience participation
- more input from indigenous groups
- venue south of city
- microphones for audience questions or paraphrase the question for the audience
- practical skills workshop, overcoming error in datasets, data analysis
- recording the presentations
- longer time for presentations, more presentations
- posters distributed more around the room and displayed over both days
- gluten free options for catering
- hand on workshops and small discussion groups
- breaking it down into different sections
- more on pressures on turtles oil and gas industry etc
- more time for questions

Do you have any other comments with respect to this Symposium or Questionnaire?

- talk about available funding for community groups
- repeat every 2 years
- very pro industry
- titles in abstract should conform with slides, presentation submitted differed to presentation on day
- parking instructions need improvement
- bi-annual
- Perth good, central location
- presenters to remain after session to answer questions from audience, too difficult to find in break
- Not too formal, good
- diversity of presentations
- hot food
- liked the short snapshot presentations, perfect timing
- funding opportunity info
- allow time after breaks for people to assemble

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