Torres Strait Dugong and Turtle Management Project

Marine Turtle Monitoring Project Report 2014-15

May 2015

Australian Government

TSRA
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Acronyms

AIMS	Australian Institute of Marine Science
AFMA	Australian Fisheries Management Authority
CCL	Curved Carapace Length
DEHP	Department of Environment and Heritage Protection
GBR	Great Barrier Reef
GBRMPA	Great Barrier Reef Marine Park Authority
JCU	James Cook University
LSMU	Land and Sea Management Unit
MTSRF	Marine and Tropical Sciences Research Facility
NERP TE	National Environmental Research Program Tropical Ecosystems Hub
NRM	Natural Resource Management
QPWS	Queensland Parks and Wildlife Services
RNTBC	Representative Native Title Body Corporate
TSRA	Torres Strait Regional Authority

Acknowledgements

The TSRA LSMU Sea Team would like to firstly thank the Traditional Owners and respective RNTBCs of Dauar and Maizab Kaur for allowing us access to your beautiful and sacred country to conduct these surveys. We would also like to extend our gracious thanks to the JCU marine turtle project team for building our internal capacity and guiding us over the years for us to get to this stage, including Mark Hamann, Shane Preston, Justin Smith and Marianna Fuentes. Our special thanks go to the QLD DEHP, in particular Andrew Dunstan and Belinda Norris, for supporting TSRA representatives to participate and learn from the Raine Island project and for your continued and supportive input into the revision of our methods and outcomes. The depth of knowledge and experience graciously provided by Col Limpus has been invaluable, as well as his patience with our revision of tag return processes and our continuous requests for past research outputs. The tireless and inspiring work of Scott Smithers and John Dawson from the College of Marine and Environmental Sciences at JCU who walked every square metre of Maizab Kaur and participated in night time surveys to help us get the job done and provide us with our first detailed look at Maizab Kaur, and its seasonal changes that impact incubating clutches. And last, but not least, to the volunteers from Mer and Erub, and TSRA LSMU staff that put in the hard yards to help complete the long surveys, sometimes through challenging conditions and to the TSRA LSMU Administration Team for organising our project logistics that got us there are back safely.

Executive Summary and Key Recommendations

This is the first comprehensive Torres Strait Marine Turtle Monitoring Project outcomes report produced by the TSRA LSMU Sea Team. This report focuses on the elaboration of the marine turtle monitoring project activities and outcomes of the Sea Team during the 2014-15 financial year while integrating the outcomes of previous research and monitoring projects relevant to the Torres Strait to give an inclusive update. It is envisaged that this report and future iterations will assist Traditional Owners, the TSRA and other stakeholders in the sustainable management of the Torres Strait's marine turtle population, while promoting the expansion to a genetic stock level of management.

During the 2014-15 breeding season the monitoring methodologies utilised by the Queensland DEHP at Raine Island, the largest green turtle rookery in the world, were adapted by the TSRA LSMU Sea Team for implementation at the marine turtle rookeries of the Torres Strait. Nesting and hatchling surveys were planned to be undertaken at the green turtle rookeries Maizab Kaur (Bramble Cay) and Dauar, the flatback turtle rookery Warul Kawa (Deliverance Island), and an initial nesting assessment of the central islands hawksbill turtle rookeries. Unfortunately, surveys at Warul Kawa and the central islands could not be completed during the 2014-15 financial year. This report summarises the results of the nesting and hatchling surveys completed at Dauar and Maizab Kaur, comparing the outcomes to previous research results where available.

Dauar:
Nesting green turtle surveys were undertaken at Dauar from the 18th - 23rd November, 2014. Hatchling green turtle surveys were undertaken 72 days after the nesting surveys from the 4th - 8th February, 2015. The 2014-15 breeding season survey outcomes demonstrate that Dauar is an ideal rookery that supports a healthy nesting green turtle population:

- Nightly nesting effort, the total number of turtles attempting to nest per night, has been high the last two breeding seasons compared to previous year's survey data indicating a large mature female green turtle demographic and an abundant food supply for the population in recent years;
- The average Curved Carapace Length of 104.1cm has not changed significantly since nesting green turtles were first tagged and measured at Dauar in 2006 indicating a stable mature female demographic;
- Nesting success, the percentage of nesting turtles that successfully lay eggs, was low at the start of the breeding season in November at both the northern (Giar, average 13.43%) and southern (Tig, average 28.6%) beaches, however, it improved significantly over the nesting period (Tig, average 80.8% in February) presumably due to the improved sand stability as a result of increased rainfall during the wet season;
- Hatching success, the percentage (%) of eggs that survive incubation and hatch, was healthy averaging 71.34% - this is the first breeding season that hatching success has been recorded at Dauar;
- Hatchling production, the total number of live hatchlings that reach representative measured sections of the rookery's shoreline per night, outcomes also indicate a high survivorship of incubating clutches when compared to the number of successful nests laid during the nesting surveys;
- The average recorded temperature at clutch depth between the survey periods indicate that hatchlings produced at Dauar would be predominantly females; and
- No marine turtle mortalities or rescues were recorded during the nesting or hatchling survey periods.

Maizab Kaur:
Nesting green turtle surveys were undertaken at Maizab Kaur from the 1st - 9th December, 2014. Hatchling green turtle surveys were undertaken 62 days after the nesting surveys from the 9th - 13th

February, 2015. The 2014-15 breeding season outcomes demonstrate that Maizab Kaur is a dynamic rookery that is exposed to high nesting green turtle densities and significant environmental factors that dramatically change and reduce its dimensions over the breeding season to the detriment of incubating clutches:

- This breeding season has recorded the highest nightly nesting effort for the rookery since surveys began in 1975, with 400 nesting turtles recorded in one night, averaging 262 per night during the nesting survey period;
- The average Curved Carapace Length of 105.5cm hasn't changed significantly since nesting green turtles were first tagged and measured at Maizab Kaur in 1975;
- Nesting success was low at the start of the breeding season in December averaging 26.44%, which didn't significantly increase over the survey period reaching only 35.1% during the hatchling surveys indicating that little rain had fallen on Maizab Kaur during the wet season;
- Maizab Kaur was mapped during the nesting and hatchling surveys using a differential GPS Real Time Kinetic Unit, which recorded a significant change in shape and loss of area (7.1%) and volume (12.4%) of the island, however, this outcome is not new as previous surveys dating back to the 1977-78 season have recorded a reduction in island area over the wet season followed by an increase in area during the dry season;
- Hatching success was very low averaging 9.83%, which was primarily attributed to complete clutch destruction by sand displacement with the changing island over the wet season and presumably the nesting activity of other green turtles;
- Hatchling productivity was surprisingly high considering the hatching success outcomes, indicating that incubating clutches that weren't destroyed by displaced sand or nesting turtles had high a hatching success;
- The average recorded temperature at clutch depth between the survey periods indicate that hatchlings produced at Maizab Kaur would be close to an even ratio of males to females; and
- In total, three nesting turtle mortalities were recorded at Maizab Kaur and during the survey periods and eight nesting green turtles were rescued from the cliff area to the south-east of the island.

The newly implemented survey methods worked very well and gave a detailed insight into the surveyed rookeries and the sampled nesting marine turtle populations; however, the outcomes are only from one breeding season. No management recommendations will be presented in this report on the basis that successive years of data are needed to identify issues or concerns at the respective rookeries. These and future outcomes need to be reported in full to respective RNTBCs, Traditional Owners, community members, project partners and other stakeholders to obtain their feedback and discuss future direction and actions.

Recommendation 1: Continue to Implement and Report on Nesting and Hatchling Survey Monitoring Methodology Outcomes.

The TSRA LSMU Sea Team has always collaborated with Traditional Owners and community members in the projects under its portfolio. This year meetings with the respective RNTBC, Traditional Owners and community members occurred prior and post surveys to obtain formal approval and to deliver and discuss initial outcomes. Community members also participated on each of the completed survey trips. Additionally, the Sea Team aims to undertake an annual project road show to deliver the results of its various projects to each community, to discuss outcomes and record feedback. Regardless of these positive actions, avenues and areas for improvement to deliver against community based priorities and concerns for marine turtles as well as supplementary beneficial outcomes should be discussed and explored with communities, partner organisations and other stakeholders.

Recommendation 2: Continue to Build on Traditional Owner Collaboration across the Torres Strait.

Despite the success of the survey methodologies improvements need to be made based on outcomes this breeding season. The method to mark clutches during nesting surveys for excavation during hatchling surveys at Dauar largely failed potentially resulting in inaccurate hatching success outcomes. An alternate or improved method for clutch marking that lasts the period between surveys needs to be developed; with the absence of a dGPS RTK Unit for use at Dauar triangulation measurements are recommended.

Recommendation 3: Improve Clutch Marking Techniques at Dauar to Record Hatching Success.

Nesting success has varied at each rookery over surveyed years with the primary observed variable being identified as sand water content, i.e. dry sand causing continued collapsing of the nest during chambering. It is hypothesised that nesting success would increase with increased rainfall during the wet season, which would improve sand integrity during nesting, in particular chambering. This hypothesis, although regularly observed, has not been quantified or correlated against recorded rainfall. An examination of this relationship will result in an improved knowledge and understanding of the inter-annual variables that impact the number of successful clutches laid each season.

Recommendation 4: Correlate Future Nesting Success Outcomes with Rainfall at all Rookeries.

Nesting green turtle densities have been high at Maziab Kaur over the last two breeding seasons in comparison to available data from previous seasons. This breeding seasons hatching success data at Maizab Kaur indicates that 38.46% of the clutches excavated were disturbed/destroyed by other nesting green turtles. This is an assumption and as with Recommendation 4, should be quantified to improve our knowledge and understanding of the relationship between nesting effort and clutch destruction by nesting turtles. Methodologies to verify this assumption need to be explored before the next breeding season surveys.

Recommendation 5: Develop Methodology to Accurately Quantify Destruction of Clutches by Nesting Turtles at Maizab Kaur.

Tagging and recapturing individual turtles is one of the only ways to obtain specific demographics and migrational patterns of marine turtles. As nesting survey participants become more experienced in monitoring methodologies, tagging output and recaptures are expected to increase providing greater insight into the variables to improve our understanding of the nesting female green turtle population trends.

Recommendation 6: Increase the tagging output during all planned surveys.

This report has also identified several gaps in the Torres Strait marine turtle monitoring project. The primary gap is an absence of structured foraging ground surveys to increase our knowledge of the marine turtle demographics that inhabit the waters. As already established the Torres Strait is a significant foraging ground for the northern GBR green turtle population. Aerial surveys have also recorded incredibly large numbers of marine turtles within the Torres Strait region. It is recommended that the process undertaken to review the marine turtle nesting and hatchling baseline survey methods should be repeated with the focus on developing structured foraging ground survey methods, utilising the same expertise and partnerships to ensure the methodology is robust and will deliver useable outcomes that will assist in Traditional Owners, regional managers and other stakeholders in the sustainable management of marine turtles.

Recommendation 7: Develop Structured Foraging Ground Surveys for the Torres Strait.

Genetic studies of nesting female flatback and hawksbill turtles have not been conducted in the Torres Strait. Considering that peak breeding seasons differ in the Torres Strait compared to other adjacent rookeries for both species genetic analysis in partnership with appropriate expertise should be completed to identify if they are a separate genetic stock and therefore identify the scope of population management required and optimal approaches.

Recommendation 8: Complete Genetic Analysis of Nesting Female Flatback and Hawksbill Turtles within the Torres Strait.

1. Introduction

This is the first comprehensive Marine Turtle Monitoring Project Report that the Torres Strait Regional Authority (TSRA) Land and Sea Management Unit (LSMU) has produced. James Cook University (JCU) has been leading a Marine turtles of the Torres Strait project since 2006, which was funded by the Australian Government's Marine and Tropical Sciences Research Facility (MTSRF) and National Environmental Research Program Tropical Ecosystems Hub (NERP TE), as well as in-kind and logistical support provided by the Queensland Department of Environment and Heritage Protection (DEHP). Annual nesting surveys were undertaken at Dauar Island since 2006 (except 2011); Maizab Kaur (Bramble Cay) since 2007 and Warul Kawa (Deliverance Island) since 2012 as part of this project. The TSRA have collaborated with JCU and provided project support since 2007, building its internal knowledge and capacity by carrying out annual surveys of the Torres Strait's marine turtle population alongside JCU researchers. The JCU Marine turtles of the Torres Strait project recently concluded in December 2014. This report marks a timely stepping stone in progress towards demonstrating the TSRA's capacity to assume the responsibility of leading and reporting on its Marine Turtle Monitoring Project.

The TSRA LSMU Sea Team is responsible for the delivery of multiple and diverse projects in relation to marine natural resource management (NRM) within the Torres Strait, most relevantly the Torres Strait Dugong and Turtle Management Project. This project provides operational support for a community-based management approach for sustainable harvest of dugong and marine turtles in Torres Strait. Marine turtle research is only one facet of the project plan that is derived from the content of the Traditional Owner endorsed Torres Strait Community Based Dugong and Turtle Management Plans. This report will focus on the elaboration of the marine turtle monitoring project activities and outcomes of the Sea Team during the 2014-15 financial year while integrating the outcomes of previous research projects relevant to the Torres Strait to give an inclusive update.

This report recognises and respects that marine turtles are an integral part of Torres Strait Islanders culture; consequently, it is envisaged that this document will form a reporting template to be reviewed annually, to build a successive baseline methodology and dataset that evolves as outcomes emerge, which assists Traditional Owners, the TSRA and other stakeholders in continuing the sustainable management of the Torres Strait's marine turtle population.

2. Marine Turtles of the Torres Strait

Six of the seven marine turtle species have been recorded in the Torres Strait region:

- Green turtle, *Chelonia mydas*: nesting and foraging;
- Hawksbill turtle, *Eretmochelys imbricata*: nesting and foraging;
- Flatback turtle, *Natator depressus*: nesting and foraging;
- Loggerhead turtle, *Caretta caretta*: foraging;
- Olive Ridley turtle, *Lepidochelys olivacea*: occasional sightings; and the
- Leatherback turtle, *Demochelys coriacea*: occasional sightings (Miller, J.D. and Limpus, C.J., 1991).

This report focuses on green, hawksbill and flatback turtles, as they are species that both nest and forage within the Torres Strait and are of cultural, national and international significance and form the vast majority of the Torres Strait marine turtle population. The following sections give a brief overview of the selected species biology.

2.1 Green Turtle – *Chelonia mydas*

The green turtle is the most researched of the marine turtle species within the Torres Strait. The nesting green turtle population of the eastern Torres Strait has been demonstrated through genetic analysis to be part of the northern Great Barrier Reef genetic stock (Figure 1) (Norman, e*t al.* 1994).

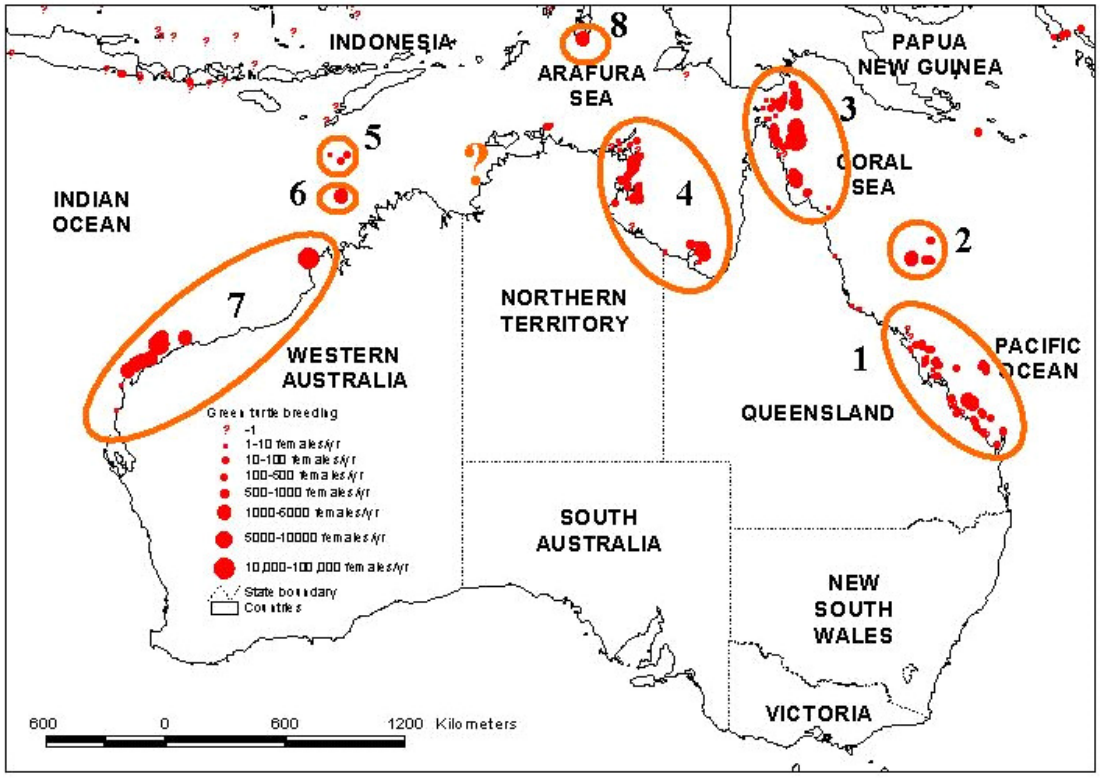


Figure 1: Genetically identified green turtle breeding stocks of Australia, with reference to three. The northern GBR population (Source: Limpus 2008)

The northern GBR stock is the largest in the world (Limpus *et al.* 2003). Nesting is concentrated on the islands and cays of the outer northern GBR and includes the major rookeries Raine Island, Moulter Cay, Number 7 and 8 Sandbanks in addition to the largest rookeries in the Torres Strait, Maizab Kaur (Bramble Cay) and Dauar Island (Limpus *et al.* 2003). For detailed data of rookery

assessments see Miller & Limpus (1991). Mating occurs annually from August through to December in the Torres Strait, with year round nesting recorded, although the majority of nesting occurs between October and March with a peak in late December and early January annually (Limpus *et al.* 2001 and 2003).

The Torres Strait is a major foraging ground for green turtles. Aerial surveys conducted in the central and western Torres Strait in November 2013 estimate the abundance of marine turtles as 617,209 (± Standard Error 83,717), of which 95% were estimated to be green turtles (Fuentes *et al.* 2015). The aerial surveys did not include the eastern Torres Strait as they were part of a long term assessment of Torres Strait's dugong population which only occur in very low densities; meaning the population estimate may be an underestimate as the surveys were undertaken during the nesting season and the eastern Torres Strait is the primary nesting ground for the region. The link between Raine Island as the major rookery and the Torres Strait as a primary foraging ground for the northern GBR genetic stock is well demonstrated. Limpus e*t al.* (1992) assessed the recorded recaptures of mature female green turtles that were tagged while nesting at eastern Queensland rookeries: of the nesting female turtles tagged at Raine Island 72.67% were recaptured in the Torres Strait, while 73.68% of those tagged in the Torres Strait were also recaptured in the Torres Strait. Fitzpatrick, e*t al.* (2012) attached satellite-linked transmitters to eight nesting females from Raine Island resulting in 75% being tracked from their post nesting migrations to foraging grounds within the Torres Strait. Tagging recaptures also demonstrate that some representatives of other green turtle genetic stocks forage within the Torres Strait, including the Coral Sea and southern GBR stocks; and that some Torres Strait nesting females forage internationally, including Papua New Guinea and the Solomon Islands (Miller & Limpus 1991). Limpus (2008) presents the only published data of immature green turtle sex-ratios from foraging grounds within the Torres Strait that were sampled from the Daru Market in southern Papua New Guinea and sourced from Warrior Reef in the Torres Strait (Col Limpus, pers. comm.); of 158 immature green turtles sampled 82% were found to be female.

2.2 Flatback Turtle – *Natator depressus*

The Australian endemic flatback turtle nests across northern and eastern Australia (Figure 2, Limpus e*t al.* 2000), with the largest rookeries for the population recorded in the western Northern Peninsula Area (Crab Island) and the western Torres Strait (Warul Kawa (Deliverance Island), Turu Cay and Kerr Islet) (Miller and Limpus 1991). Nesting female flatback turtles sampled at rookeries in eastern Queensland and the Arafura Sea show that there is a reduced gene flow, indicating a separate genetic stock between the regions (Pittard 2010); however, it should be noted that genetic samples of flatback turtles were taken at Crab Island during the various genetic analysis projects (FitzSimmons *et al.* 1996; Pittard 2010), not Warul Kawa (Deliverance Island), Turu Cay or Kerr Islet.

There has been limited annual monitoring of the flatback turtle population within the Torres Strait. Aerial surveys were conducted during the green turtle breeding seasons in 1975/76, 1976/77, 1977/78 and 1978/79 (Kowarsky 1978, Miller & Limpus 1991) and around the islands and cays of the western Torres Strait in July 1999 (Limpus e*t al.* 2000). The first nesting beach surveys were undertaken at Warul Kawa, Kerr Islet and Turu Cay over a two day period in February (Warul Kawa), a two day period in September (Turu Cay) and from the 28th September - 15th of October (Warul Kawa and Kerr Islet), 1987 (Limpus e*t al.* 1989). Short period monitoring surveys (three nights) were undertaken by JCU in September 2012, February 2013, August 2013 and March 2014 (Hamann *et al.* 2015a). Nesting has been recorded year round in northern Australia; however, there is variation in breeding seasons across their northern Australia distribution (Limpus *et al.* 1983, Hamann *et al.* 2015a). The nesting season for Crab Island is recorded between July and September annually, with a peak in August (Limpus *et al.* 1983). Comparatively, the nesting season at Warul Kawa falls in the earlier months of the year between February and April (Limpus e*t al.* 1989, Hamann *et al.* 2015a). Satellite tags deployed during the JCU project demonstrated that the majority of nesting females:

- Spent their breeding cycle (period between nesting attempts) within 25km of the rookery; and
- Migrated variable distances (100-2,000km) in a typically westerly direction to their foraging grounds in the Gulf of Carpentaria, Arafura Sea and Bonaparte Gulf, which includes the utilisation of Indonesian and Papua New Guinean waters (Figure 3, Hamann *et al.* 2015a).

No reports, data or outcomes on flatback turtle foraging ground demographics could be identified for the Torres Strait.

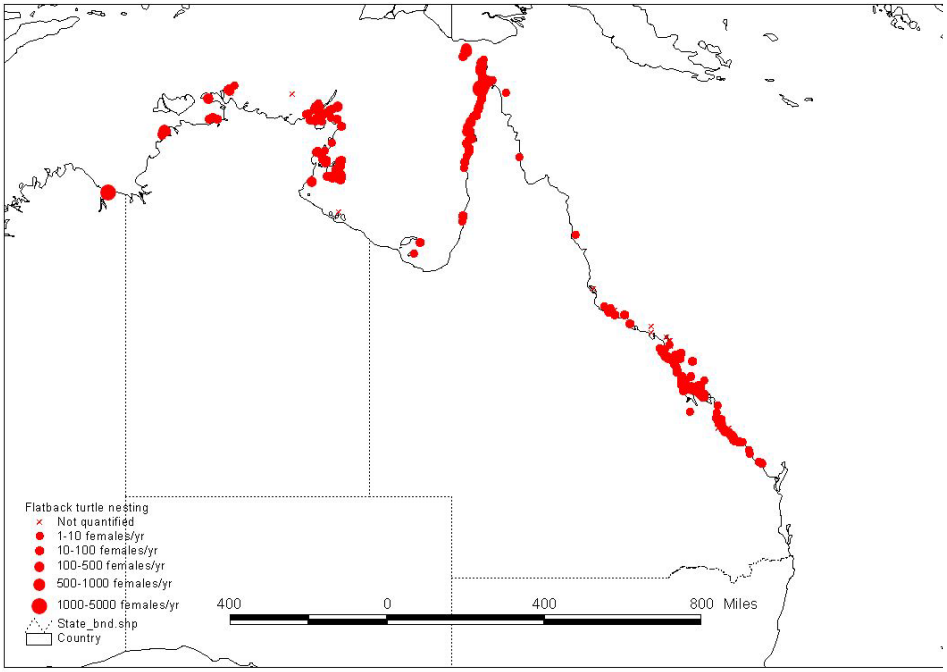


Figure 2: Distribution of flatback turtle nesting in northern and eastern Australia (Source: Limpus *et al.* 2000)

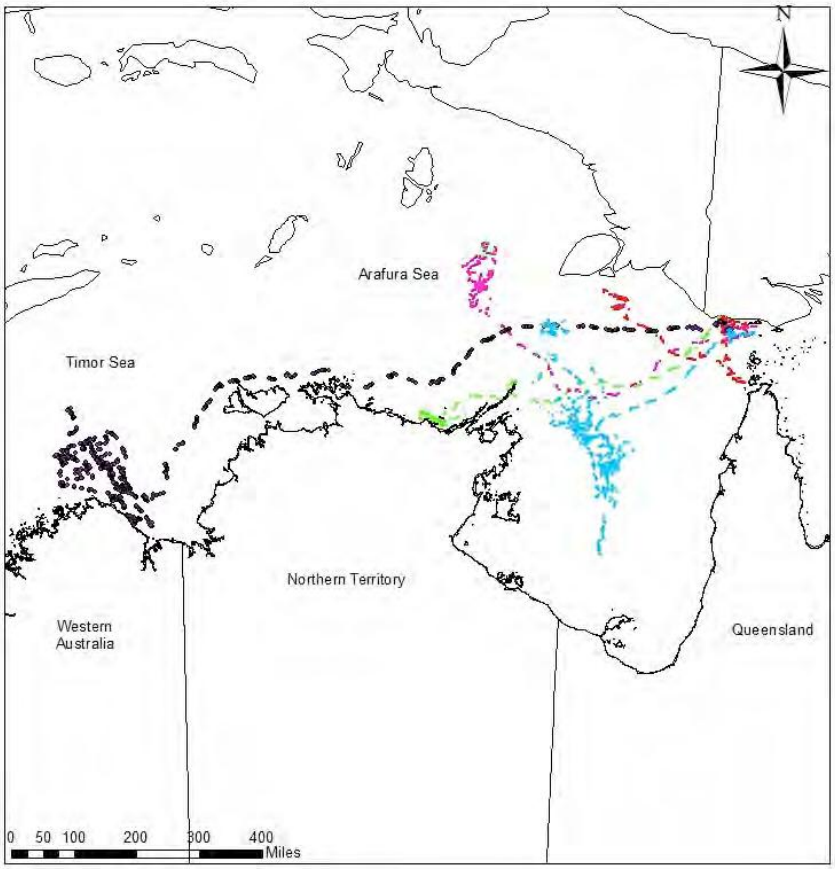


Figure 3: Migration routes and foraging areas for five female flatback turtles after nesting at Warul Kawa in 2013 (Source: Hamann *et al.* 2015a)

2.3 Hawksbill Turtle – *Eretmochelys imbricata*

The hawksbill turtle is the least researched of the marine turtles that nest in the Torres Strait. As with the initial green turtle and flatback turtle population assessments aerial surveys were undertaken in conjunction with green turtle nesting surveys in the late 1970's (Kowarsky 1978, Miller and Limpus 1991).

Limpus e*t al.* (1983) undertook the first detailed study of an Australian nesting population of hawksbill turtles on Campbell Island from the 1st of December 1978 to the 16th of February 1979. Campbell Island was previously identified as an important hawksbill turtle rookery alongside Sassie Island (Long Island); however, Campbell Island was selected for logistical project support reasons over Sassie Island to conduct the survey (Limpus e*t al.* 1983). Low density nesting of hawksbill turtles was recorded for the survey period, only 22 nesting hawksbill turtles were tagged over the two and a half month period (Limpus e*t al.* 1983). Regardless Limpus e*t al.* (1983) presents inclusive outcomes of nesting female hawksbill turtle biology, the only completed and thorough field surveys for the species in the Torres Strait.

Since this initial field survey two aerial surveys within the Torres Strait have been dedicated to the nesting hawksbill turtle, including February 1997 that surveyed the eastern and central Torres Strait, and in July 1999 that surveyed the western Torres Strait (Limpus e*t al.* 2000). The results of the aerial surveys have identified a nesting distribution for the species around Australia (Figure 4), which have highlighted the northern Great Barrier Reef, central and eastern Torres Strait and eastern Arnhem Land as some of the most significant nesting populations in the world (Limpus e*t al.* 2000). The hawksbill nesting population of the northern GBR and Torres Strait has been identified as an

independent management unit for the species (Fitzsimmons & Limpus 2014), independent of the populations that breed in north-east Arnhem Land and the Solomon islands.

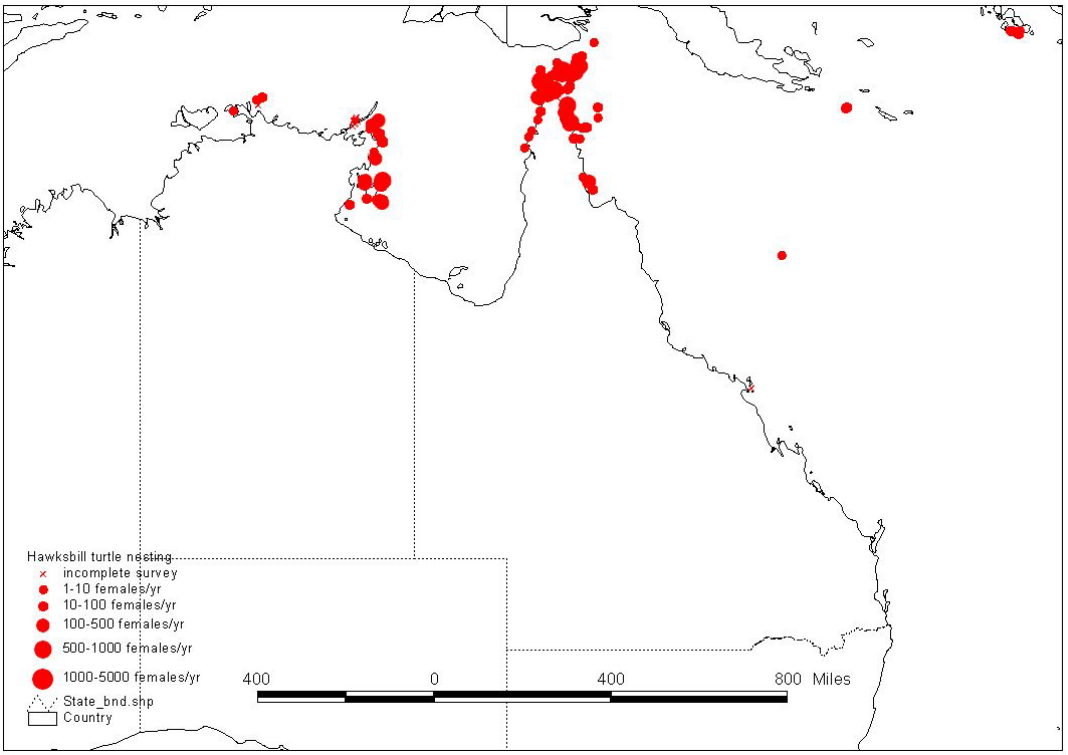


Figure 4: Distribution of hawksbill turtle nesting in northern and eastern Australia (Source: Limpus, C.J., *et al.* 2000)

As with other marine turtle species nesting in the Torres Strait, nesting has be recorded all year round, with the peak of the breeding season for the northern GBR population identified from December to February annually (Limpus *et al.* 2000). Aerial surveys identified Sassie Island, Hawkesbury Island and Dayman Island as the rookeries with the highest nesting activity within the Torres Strait, which had estimates of greater than 500 nesting females per year in 1997 (Limpus *et al.* 2000). This outcome contradicts anecdotal evidence from Traditional Owners in the Torres Strait, which have identified September as the peak nesting period for hawksbill turtles. Considering aerial surveys have not previously been undertaken in September and the only dedicated field survey was undertaken on a low density hawksbill turtle rookery, it is recommended future monitoring consider both February and September months to identify the peak nesting period for the Torres Strait.

The limited nesting surveys accompanied with no structured foraging surveys within the Torres Strait has resulted in:

- Minimal tags applied to the nesting or foraging hawksbill turtle population of the Torres Strait;
- Recaptures or tag returns from other nesting and foraging surveys are non-existent as there has been not been any structured monitoring of rookeries or foraging grounds; and
- The hawksbill turtle is not traditionally harvested within the Torres Strait, meaning that there are no tag returns from traditional hunters.

Accordingly, there are no reports, data or outcomes on hawksbill turtle migrations or foraging ground demographics for the Torres Strait region.

3. Method Development

The JCU *Marine turtles of the Torres Strait project* utilised the standard methods of the Queensland Government (Hamann, M., *et al.* 2015a; 2015b), which included on saturation tagging of nesting female turtles from dusk until approximately midnight, timing the monitoring of nesting beaches with high tides that peaked within the early evening, followed by morning after track counts to record capture-mark-recaptures, nesting effort and success, curved carapace lengths and distinguishable features data. This method functioned well in previous breeding seasons over the course of the project (since 2006) as the methods rely on relatively small to average numbers of nesting females to accurately record each of the parameters of the survey. However, during the 2013/14 breeding season the nesting effort was incredibly high at both Dauar and Maizab Kaur, rendering the saturation tagging and morning after track count methods ineffective to accurately record nesting effort and success at the rookeries for the breeding season. It is estimated that the highest night's nesting effort at Dauar was approximately 300-500 (both Tig, the southern beach, and Giar, the northern beach) while at Maizab Kaur it was approximately 600-800 nesting green turtles (Tristan Simpson LSMU Senior NRM Officer (Sea), Pers. Comm.). Although track counts were attempted in the morning, they were incredibly inaccurate given the high nightly nesting densities. The result was methodology that only recorded a sample of the nesting population's capture-mark-recaptures and curved carapace lengths.

It was also recognised that the methodology did not incorporate the marking of clutches laid during nesting surveys for excavation during hatchling surveys to determine hatchling success. The project hatchling survey methodology only excavated observed emerged clutches to determine hatchling success, therefore it is expected that the results would be positively biased towards higher hatchling success as the methods could not account for undeveloped or destroyed clutches.

In discussions with JCU representatives over the methodology and outcomes of the high density 2013/14 breeding season it was collaboratively decided to increase the parameters of the surveys undertaken that accounted for high nesting effort seasons while maintaining compatibility with low/average nesting effort season methodology for annual comparison of outcomes. Based on the foundational capacity building work during the JCU *Marine turtles of the Torres Strait project* it was also recognised that TSRA LSMU rangers were capable of completing more rigorous methodology.

The TSRA supported the Queensland DEHP Raine Island Recovery project, which also included TSRA LSMU staff participation in the project and associated surveys. Raine Island is subjected to incredibly high nesting effort densities of green turtles and specific methodologies have been developed to record the parameters of the nesting females. In discussions between DEHP, JCU and TSRA it was decided to adapt the Raine Island methodologies to the Torres Strait's rookeries using available resources. The TSRA drafted the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* document, which was circulated to JCU and DEHP for review.

In order to facilitate the methodology review the TSRA requested a face to face Torres Strait Marine Turtle Workshop with project partners and stakeholders, which occurred on the 9th October, 2014 at the JCU Townsville campus. The workshop was attended by representatives from TSRA (9), JCU (3), Queensland DEHP (4), GBRMPA (1) and the Australian Fisheries Management Authority (AFMA) (1).

Figure 5: Participants of the Torres Strait Marine Turtle Workshop held at the JCU Townsville campus, 9th October 2014.

The objectives of the workshop were to:

- Increase the TSRA's knowledge and understanding of marine turtle monitoring and research outcomes to date within the Torres Strait and adjacent regions (i.e. Cape York and Raine Island);
- Discuss and finalise the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* and associated processes, including:
  - Training of field trip participants;
  - Communication of outcomes: community, regional and national;
  - Collaboration with other stakeholders involved in marine turtle management and/or monitoring/research in adjacent regions outside of the Torres Strait; and
  - Returning turtle tags; and
- Identify monitoring and research gaps and priorities and develop strategies to address them.

The *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* was first implemented during the 2014-15 breeding season and will be reviewed prior to the next breeding season. For full outcomes of the workshop please see Appendices 2. Torres Strait monitoring and research gaps will be covered in a subsequent section.

The following subsections briefly elaborate on the final methodologies that were implemented during the 2014-15 breeding season. Some constructive criticisms against these methods were made during the workshop; where appropriate these will be clarified and accompanied by a justification on the final methods selection.

3.1 Rookery Monitoring Locations

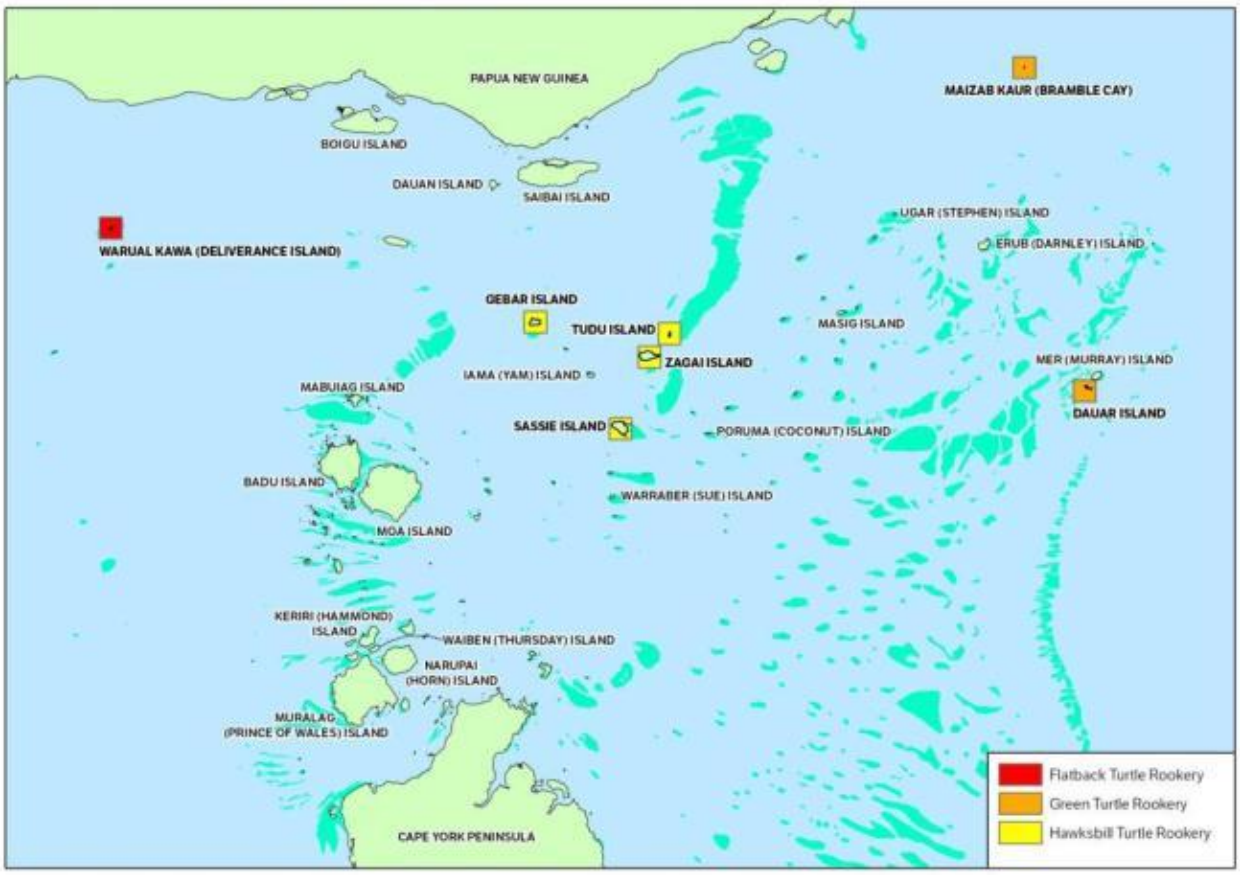


Figure 6: Distribution of rookeries monitored as part of the TSRA's Torres Strait Dugong and Turtle Management Project – Red = Flatback Turtle Rookery; Orange = Green Turtle Rookeries; Yellow = Hawksbill Turtle Rookeries.

3.1.1 Green Turtle Rookeries

Maizab Kaur (Bramble Cay) is a small uninhabited sand cay with a phosphate rock surface that has formed as a result of a substantial sea bird population that also uses the island as a rookery. The island is situated on the western edge of a fringing coral reef located in the North East sector of the Torres Strait approximately 241km east of Thursday Island and 47km North of Erub (Darnley Island). Maizab Kaur is the largest green turtle rookery in the Torres Strait and is located within the Erubam Le Turtle and Dugong Management Plan Area.

Dauar is a small uninhabited volcanic Island that is well vegetated three kilometres south-west of Mer (Murray Island) and 209km East of Thursday Island. Dauar is the second largest green turtle rookery in the Torres Strait and is located within the Mer Gedkem Le (TSI) Corporation RNTBC Turtle and Dugong Management Plan Area.

3.1.2 Flatback Turtle Rookery

Warul Kawa (Deliverance Island) is a small uninhabited sand cay surrounded by a large intertidal sand flat in the north western sector of the Torres Strait approximately 200km north of Thursday Island and 65km west of Boigu Island. It is the largest flatback turtle rookery in the Torres Strait and is located within the Malu Ki'ai Turtle and Dugong Management Area.

3.1.3 Hawksbill Turtle Rookeries

The central islands of the Torres Strait are located within the Magani Laguagal Turtle and Dugong Management Area: the Wakeyama RNTBC are the representative Traditional Owners of Sassie Island, the largest of the hawksbill turtle rookeries in the Torres Strait and potentially Australia; the Magani Lagaugal RNTBC are the representative Traditional Owners of Tudu and Zagai islands; while the Gabaralgal RNTBC are the representative Traditional Owners of Gebar Island.

3.2 Rookery Monitoring Schedule: Financial Year

Table 1: Torres Strait Rookery Monitoring Schedule

Month	Survey	Comments
September	Sassie Island and Other Central Islands – Hawksbill Nesting Surveys	• The peak nesting period is unconfirmed with contradictory recommendations – it is recommended that nesting surveys be undertaken in September and January/February to confirm the peak nesting period (this will be further discussed in the monitoring gaps section); • Due to the limited number of surveys completed for hawksbill turtles these surveys aim to assist in the development of a more comprehensive monitoring plan by identifying the peak nesting season and rookeries of greatest significance (e.g. density, cultural, or concern); • A minimum of five survey days are required to complete the methods which involves daily visits to each rookery.
November	Dauar – Green Turtle Nesting Surveys	• Although early in the breeding season, the nesting survey at Dauar is completed within the last two weeks of November to allow monitoring of Maizab Kaur closer to the peak of the nesting season; • A minimum of seven survey nights are required to complete the methodology; and • The surveys are timed to coincide with the high tide peak close to sunset at the start of the survey for consistency and to facilitate annual comparison of outcomes.
December	Maizab Kaur – Green Turtle Nesting Surveys	• The nesting survey at Maizab Kaur is completed within the first two weeks of December; • A minimum of seven survey nights are required to complete the methodology; and • The surveys are timed to coincide with the high tide peak close to sunset at the start of the survey for consistency and to facilitate annual comparison of outcomes.

Month	Survey	Comments
February	Dauar and Maizab Kaur – Green Turtle Hatchling Surveys	• Hatchling surveys are timed to be completed approximately 65 days after nesting surveys to ensure enough time for incubation; • A minimum of four survey nights are required at each rookery to complete the methodology, aimed to be within the first two weeks of February; • The methods are not tide dependant.
March	Warul Kawa – Flatback Turtle Nesting Surveys	• The peak nesting period has been identified between February and April for the rookery, the surveys are aimed to be completed around the start of March, pending ideal tides the surveys can be undertaken in late February or mid-March; • Access to the rookery is tide dependant and can only occur around high tide (± 2 hours) due to the large sandy reef flat, the surveys need to be timed to coincide with the high tide peak close to sunset at the start of the survey to ensure access to the rookery during the times nesting flatbacks can access the rookery; • A minimum of four survey nights are required to complete the methodology.
May	Warul Kawa – Flatback Turtle Hatchling Surveys	• Hatchling surveys are timed to be completed approximately 65 days after nesting surveys to ensure enough time for incubation; • A minimum of four survey nights are required to complete the methodology, aimed to be within the first two weeks of May; • The methods are tide dependant as per the March Surveys.

Methodology Discussion

The primary comment from the Townsville Torres Strait Marine Turtle Workshop was directed towards the monitoring of the green turtle rookeries. The only complete northern GBR green turtle population breeding season data set was recorded at Maizab Kaur (Limpus e*t al.* 2001). Based on this data the peak nesting period has been identified between the end of December and the start of January annually. During the workshop it was strongly recommended to undertake the nesting surveys during the first two weeks of January to capture the period when the majority of nesting female turtles are present and for a duration of two weeks to cover the average recorded breeding cycle of 12 days (as per Limpus e*t al.* 2001). This recommendation was accompanied with the provision that obtaining accurate population trends for marine turtles requires decades of saturation tagging to detect any changes.

Unfortunately there are many factors preventing monitoring from occurring during the recommended period at the selected rookeries and using the recommended methods:

- The high density of nesting green turtles that prevents complete saturation tagging and would inevitably promote disturbance of nesting turtles;
- The remoteness of the rookeries that requires vessel support (Maizab Kaur especially) and subsequent resources to fund the project and vessel hire for the recommended duration that would prevent the completion of hatchling surveys;

- The TSRA's Enterprise Bargaining Agreement prevents a prolonged, intense survey that accrues overtime above the allowable limit for participating staff; and
- Inadequate staffing available to complete the surveys near the mandatory office closure period (Christmas and New Year).

It was proposed that the surveys be undertaken in concurrence with the Raine Island surveys, to separate the monitoring period to capture both nesting and hatchling outcomes and facilitate comparison of outcomes. It is noted that the selected periods or methods are not optimal (as per Limpus e*t al.* 2003), but a necessity to capture accurate and useable data for high nesting densities that will allow comparative annual analysis of nesting and hatchling outcomes specific to the monitored rookery. In the future, there may be potential to accommodate the recommendations and they should be seriously re-considered where possible.

3.3 Monitoring Methods

For full method details please see the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* document. Table 2 briefly identifies and describes the methodologies employed by the TSRA LSMU Sea Team for monitoring nesting and hatchling marine turtles at key rookeries.

Table 2: Summary of Marine Turtle Nesting and Hatchling Baseline Survey Methods in the Torres Strait

Method	Comments
Morning After Track and Nest Count	• The primary method to assess the hawksbill turtle rookeries of the central islands, and survey beaches that are not monitored throughout the night time surveys, including Tig (southern nesting beach, Dauar) and Warul Kawa. • The method involves recording from the previous night the species composition (track identification), nesting effort (total number of turtles attempting to nest per night), nesting success (percentage of turtles that successfully lay eggs) and recording any visible damaged to clutches (e.g. predation) the morning after, crossing off tracks above the high tide line and nests to prevent duplicate recordings.
Tagging: Capture-Mark-Recapture	• A primary method undertaken during all night survey periods, the aim of which is to tag (Stockbrands Co PTY LTD Titanium Turtle Tags) or recaptured tagged turtles, measure (curved carapace length CCL (cm) and record distinguishing features (e.g. injuries, illness) as many nesting turtles as possible (haphazardly and opportunistically if densities are high) without disturbing turtles attempting to nest, including: only tagging turtles that have successfully nested or are returning to the water; not tagging turtles emerging to nest; and avoiding tagging turtles in close proximity to other turtles attempting to nest. • Tagging works in conjunction with other methods to ensure that accurate nesting effort and success data is collected.

Method	Comments
Nesting Effort and Success	• This method is conducted over a minimum of three full consecutive nights (18:30-06:30) at Dauar (Giar, northern nesting beach), Maizab Kaur and Warul Kawa for the duration that the tides allow access to the survey beach (4-6 hours). • The method involves survey teams patrolling the rookery recording and marking every nesting turtle with a small dot of spray paint above the left front flipper (as discretely as possible, from behind) once they have exited the water and are less likely to be disturbed, then recording the total number successful nests observed as well as the number of disturbed clutches observed. • If nesting effort is low and all nesting turtles can be accurately accounted for without marking this method does not need to be completed as the tagging method can also record nesting effort and success.
Nesting Effort Snapshot	• This method is conducted at 21:00 on three nights over the survey period at Dauar (Giar, northern nesting beach) and Maizab Kaur. • A survey team walks the full perimeter of the nesting beach, equally spaced across the beach slope perpendicular to the shoreline counting every turtle present on the rookery at that time. • The current methods have not been implemented during a high density breeding season, this method is conducted to provide a simple comparison between high and low density breeding seasons, and by using the outcomes of the nesting effort and success surveys potentially provide an estimate of total nesting effort if needed.
Hatching Success	• This method requires that clutches that are representative of the entire rookery are marked (clutch tag and differential GPS or hand held GPS and stake) and details recorded (date, latitude/longitude, clutch depth and count) during the nesting survey and relocated, excavated and clutch development categorised (hatched shells, undeveloped, unhatched, and live and dead hatchlings) during the hatchling survey. • If nesting densities are low clutches are marked in conjunction with tagging during the entire survey period, if nesting densities are average to high clutches are marked in conjunction with tagging for two nights separate from the nesting effort and success method. • Clutches are excavated during the day of the hatchling surveys, three full days are dedicated to excavating clutches; pending the number of clutches marked during nesting surveys daytime surveys aim to excavate as many of the clutches as possible that are representative of the rookery.
Hatchling Production	• This method is conducted over a minimum of three full consecutive nights (18:30-06:30) at Dauar (Giar, northern nesting beach) and Maizab Kaur and Warul Kawa for the duration that the tides allow access to the survey beach (4-6 hours). • The method involves digging and maintaining measured trenches along the perimeter of the rookery at representative locations, above the high tide line in order to capture, count and release hatchlings for the survey period.

Method	Comments
Temperature at Clutch Depth	• Three temperature loggers (Thermodata DS1921G Fob Fitted Thermochron, ±0.5°C) that are sealed in a clear plastic tube (waterproofing) are buried to a depth of 50cm, recorded (hand held GPS coordinates and photos) and marked (flagging tape and a marker pole) at representative locations around each rookery where there is minimal (as possible) chance of disturbance by nesting turtles during the nesting surveys. • The temperature loggers are excavated during the hatchling surveys for analysis.
Mortality and Rescue	• All marine turtle mortalities and rescues are recorded (species, location, hand held GPS coordinates, tags (if present), CCL and cause) for the duration of the survey at each rookery.
Rookery Geomorphology	• This method is only conducted at Maizab Kaur as it is a highly dynamic, low lying sandy cay that changes dimensions with the changing seasons that includes a transition from south easterly to north westerly trade winds around December/January annually. • This method was completed by a JCU representative, and involved the use of permanent reference points and a differential GPS RTK Unit to map the entire rookery during the nesting and hatchling surveys.
Rookery Photographic Record	• This method involves taking a photographic record of the rookery during each survey period, including: the rookery from an elevated position; beach profiles; vegetation; sea birds and other species observed; noticeable changes observed between seasons; and any other points of significance. • Photos are stored electronically for visual reference as needed pending outcomes and need to demonstrate or facilitate communication of outcomes.

4. Survey Completion: 2014-15

Table 3: Completion status of 2014-15 Torres Strait marine turtle surveys

Survey	Status	Comments
Sassie Island and Other Central Islands – Hawksbill Nesting Surveys	Incomplete	• TSRA ranger vessels were planned to be used as transport to each of the rookeries to complete the surveys. • Unfortunately, the vessels were not operational for the required survey period and prevented completion of the surveys. • The TSRA ranger vessels are now operational and the surveys should be completed in the 2015-16 financial year.
Dauar – Green Turtle Nesting Surveys	Complete	• The surveys and all planned objectives were completed between the 18th and 23rd November 2014. • Survey Team Participants: Tristan Simpson (project leader), Aaron Bon (Mer Ranger), Taukie Passi (Mer Ranger), Mark Pearson (Warraber Ranger), Loice Naawi (Masig Ranger), Noel Baker (Ugar Ranger), Shanice Havili (TSRA Ranger), and the Mer volunteer Josia Cunningham.
Maizab Kaur – Green Turtle Nesting Surveys	Complete	• The surveys and all planned objectives were completed between the 1st and 9th of December 2014. • Survey Team Participants: Tristan Simpson (project leader), Boggo Gela (Senior Erub Ranger), Wallace Gela (Erub Traditional Owner and volunteer), Lieu (Noel) Anson (Erub Traditional Owner and volunteer), Matthew Dunn (Senior Ranger Supervisor), Tenny Elisala, Ted Whap (Mabuyag Ranger), Gerald Bowie (Ranger Supervisor), Anthony Drummond (TSRA Ranger), Scott Smithers (JCU – Geomorphologist), Shane Preston (JCU – Researcher), and Scott Gardner (AIMS Engineer).
Dauar and Maizab Kaur – Green Turtle Hatchling Surveys	Complete	• Dauar hatchling surveys and all planned objectives were completed between the 4th and 8th February 2015, Maizab Kaur hatchling surveys and all planned objectives were completed between the 9th and 13th February 2015. • Dauar Survey Participants: Tristan Simpson (project leader), Aaron Bon (Mer Ranger), Taukie Passi (Mer Ranger), Troy Stow (Ranger Supervisor), Laura Pearson (Warraber Ranger), Loice Naawi, John Tabo (Dauar Traditional Owner and Mer community member). • Maizab Kaur Survey Participants: Tristan Simpson (project leader), Aaron Ketchell (Erub Ranger), David Ghee (Erub Ranger), Ted Whap (Mabuyag Ranger), Anthony Drummond (TSRA Ranger), Erin McGinty, Barry Pau (Erub Traditional Owner and Volunteer), Charles Thaiday (Maizab Kaur Traditional Owner and Volunteer), and John Dawson (JCU – Geomorphologist)

Survey	Status	Comments
Warul Kawa – Flatback Turtle Nesting Surveys	Incomplete	• Nesting surveys were planned to be completed at Warul Kawa in conjunction with an Indigenous Protected Area Ranger Trip from the 22nd to 28th February 2015. • Unfortunately the vessel chartered to transport and accommodate participants while on survey sank several hours after arrival to Warul Kawa and vessel crew and participants had to abandon ship to await rescue (a separate incident report was completed and submitted). • Subsequently no flatback nesting surveys were completed during the 2014-15 financial year for the following reasons: – Other planned Sea Team activities during the remaining peak breeding season period; – All monitoring equipment was lost when the vessel sank; and – Survey participants were shaken from the event and there was hesitation from some to participate so soon after the event.
Warul Kawa – Flatback Turtle Hatchling Surveys	Incomplete	• Hatchling surveys were planned to be completed at Warul Kawa in May 2015; however, as no nesting surveys were completed there was no point in completing hatchling surveys, which require nesting survey data.

Sections 5 and 6 of this report will focus on the outcomes of the completed Dauar and Maizab Kaur surveys. As no surveys took place on the flatback and hawksbill turtle rookeries they will not be discussed further.

5. Dauar Survey Outcomes and Discussion

Nesting green turtle surveys were undertaken at Dauar from the 18th - 23rd November, 2014. Hatchling green turtle surveys were undertaken at Dauar 72 days after the nesting surveys, from the 4th - 8th February, 2015. Each of the survey participants were provided with training that included a detailed training document and presentation explaining the monitoring schedule and methods that was derived from the content of the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* document. During the nesting survey the first night of the survey was dedicated to practical training of each of the methods, which was followed by six nights of survey to complete the objectives. During hatchling surveys practical training was provided at the start of each different activity. This was satisfactory as there were a reduced number of methods and the methodology simpler. Additionally, participants with previous experience were paired with participants with no or limited experience. VHF radios were used so that if any questions or concerns surfaced during the survey they could be answered by the project leader.

5.1 Traditional Owner Collaboration

Nesting Survey
Prior to beginning of the nesting survey formal written approval was obtained from the Mer Gedkem Le (TSI) Corporation RNTBC to undertake the surveys.

Tristan Simpson and Aaron Bon (Senior Ranger Mer) met with the Mer Gedkem Le (TSI) Corporation RNTBC, including Doug Passi (Chair) and Aven Noah (Deputy Chair), prior to the start of the nesting survey to discuss the project and intended activities, as well as discuss previous outcomes. Formal permission was again granted to undertake the project. Tristan Simpson and Aaron Bon also met with James Zaro, Dauar Traditional Owner, prior to the nesting survey to discuss the project. Mr Zaro was disappointed that formal approval to undertake the project on Dauar had not also been sought from him as a Traditional Owner of the country we were intending to work on. In the future he requested that formal approval be also sought from him. Mr Zaro gave verbal permission to undertake the project on Dauar.

A volunteer from Mer (Murray Island), Josia Cunningham, participated in the survey and was trained in the methodology. It was originally planned to have two Mer community participants; however, the second volunteer had to pull out of participating in the survey at the last minute due to work commitments and no other volunteer could be found given the short notice. During the survey period Doug Passi visited the chartered vessel for a night and accompanied staff onto the rookery to observe both night and morning surveys. James Zaro also visited the chartered vessel during the survey for an evening to meet with staff and discuss how the project was going.

The data collected was entered into a database over the course of the survey. The intent of this was to have the initial results of the survey ready to present to the Mer Gedkem Le (TSI) Corporation RNTBC and James Zaro at its conclusion. Tristan Simpson and Aaron Bon presented the survey outcomes to Doug Passi and Aven Noah, RNTBC Chair and Deputy Chair respectfully, and to James Zaro prior to departing Mer. This also gave the opportunity to ask any questions and list any concerns regarding the project. It was greatly appreciated and is highly recommended to continue this level of collaboration.

Hatchling Survey
Prior to beginning the hatchling survey formal written approval was obtained from the Mer Gedkem Le (TSI) Corporation RNTBC and James Zaro to undertake the surveys.

Tristan Simpson and Aaron Bon met with James Zaro before the start of the survey in order to discuss the project and obtain formal approval to visit and survey on Dauar. The Mer Gedkem Le (TSI) Corporation RNTBC Chair Doug Passi and Deputy Chair Aven Noah were not present on Mer at the time of the survey; however, written permission had been obtained from the RNTBC prior to arrival.

A Mer volunteer, John Tabo, also participated in the surveys and was trained in the methodology. As with the nesting surveys a second volunteer was meant to participate; however, for an unknown reason the volunteer did not show up and a replacement could not be found. James Zaro visited the chartered vessel during the survey again to meet with staff and discuss how the project was going.

Tristan Simpson met with James Zaro at the conclusion of the survey to present and discuss the outcomes of the project. This was appreciated by James Zaro and it should be noted to continue and build on this level of collaboration and communication.

5.2 Nesting Effort and Success

There are two primary nesting beaches on Dauar: Giar, the northern nesting beach and Tig, the southern nesting beach. Nesting effort, total number of nesting turtles, and nesting success, percentage of total number of nesting turtles that successfully laid eggs, were recorded on both Giar and Tig.

Three full nights of nesting effort and success surveys were completed at Giar from 18:30 to 06:30 on the 19th - 21st November, 2014; however, due to survey staff shortages the entire nesting beach measuring approximately 881m along the high tide line could not be accurately surveyed throughout the night. A section of the nesting beach was marked out and recorded (hand held GPS) on the afternoon of the 19th November using bamboo found on the island to define the monitoring section to complete the survey (Figure 7). The section measured 348m (39.5%) of rookery shoreline (high tide line). After completing the first night of the survey it was discussed and agreed amongst participants that we could expand the monitoring section and still accurately collect the survey data with the aim of increasing the representative portion of the nesting beach surveyed (Figure 7). The section measured 522m (59.3%) of rookery shoreline (high tide line).

The southern nesting beach, Tig (Figure 7), was surveyed over six mornings from the 19th - 24th November 2014 using the Morning After Track and Nest Count method, which records nesting effort and success for the beach as well as damaged or disturbed nests (e.g. predation).

Figure 7: Dauar showing the primary nesting beaches a) Giar and b) Tig; and the surveyed sections on the 19th November and 20-21st November, 2014.

The average nesting effort recorded on the defined survey sector of Giar was 75.00 (range 48-112, SD 33.15, n=3), while the average nesting effort recorded on Tig was 56.5 (range 37-71, SD 12.06, n=6). At the conclusion of one survey period (20/11/2014) there were five green turtles still nesting; nesting success was not observed for these green turtles and they were not included in the nesting success calculations.

As a total, nesting effort for Giar and Tig ranged from 102 (20/11/2014) to 170 (21/11/2014), which didn't include 40.7% of the Giar nesting beach, meaning there were more unrecorded turtles on the nesting beach. In hindsight, the unmonitored section of Giar should have been included in the Morning After Track and Nest Count method to complete the data for the rookery. It should be noted that in seasons with high nesting effort the Morning After Track and Nest Count in the unsurveyed sections will be difficult and more than likely garner inaccurate results. It would be preferred to ensure adequate staff are available to complete the survey.

Regardless, it still gives an indication of the total number nesting at Dauar. Using the cumulative arrival and departure of nesting female green turtles at Maizab Kaur, 1979-80 breeding season table (Limpus e*t al.* 2001), which is the only complete breeding season record for a northern GBR green turtle nesting population, the survey period was conducted during the arrival period where approximately only 27.66%-36.39% of turtles would have arrived. Using these very approximate figures and the highest nesting effort recorded, as a minimum number present and assuming nesting turtles did not migrate between nesting beaches on the same night, the total nesting effort during the peak of the season could have reached 467.16 (36.39% value) - 614.61 (27.66% value).

Historically there is not much data to compare this outcome to, aside from the more recent surveys undertaken from 2006-2014 by JCU (Hamann et al. 2015b). An aerial survey undertaken on the 10th November 1975 recorded only one fresh green turtle track, and on the 2nd January 1976, during peak breeding season, again only one fresh green turtle track was recorded (Kowarsky 1978). Aerial surveys were also completed during the 1977-78 and 1978-79 breeding seasons (undefined dates); Dauar was recorded as 'nil' for the 1977-78 season and an estimated abundance of 10-20 nesting green turtles in the 1978-79 season. The methodologies used during the *Marine turtles of the Torres Strait Project* were variable between seasons, in particular survey locations and sections at Dauar (see Hamann et al. 2015b), which makes it difficult to compare the outcomes of the projects data to the 2014-15 breeding season nesting effort outcomes. Clarification on the monitoring locations is needed before annual comparisons can be made.

Nesting success was low during the November survey period, averaging 13.43% (range 10.71-15%, SD 1.93, n=3) on Giar and 28.6% (range 18.64-46.94%, SD 10.79, n=6) on Tig. The primary observed reason for the low nesting success was dry sand causing continued collapsing of the nest during chambering (anecdotal, not quantified). It is recommended for the next breeding to record these observations to assist in quantification. It was hypothesised that nesting success would increase with increased rain during the wet season of the Torres Strait, which would improve sand integrity during nesting, in particular chambering.

In order to support this hypothesis, three days of Morning After Track and Nest Count method were completed on Tig from the 5th - 7th February, 2015. The average nesting effort was 19 (range 9-27, SD 9.17, n=3), while the average recorded nesting success significantly increased to 80.8%, an increase of 52.2% (range 57.74-100%, SD 21.77, n=3, t-test: $t(7)=5.00$, $p=0.0015$). The 2006-07 breeding season is the only other breeding season with data collected before the wet season (late November, early December) and during the wet season (late January, early February), reporting a similar trend with a lower average nesting success before the wet season (average 23.9%, SD 13.75, n=9) compared to the wet season (average 47.3%, SD 21.4, n=6).

Nesting success has been variable at Dauar since it was first surveyed in the 2006-07 breeding season (Table 4).

Table 4: Average nesting success at Dauar during November and December (pre wet season) for breeding seasons surveyed.

Breeding Season	Average Nesting Success (%)	Source
2006-07	24	Hamann et al. 2015b
2007-08	62	Hamann et al. 2015b
2008-09	60	Hamann et al. 2015b
2009-10	60	Hamann et al. 2015b
2010-11	68	Hamann et al. 2015b
2012-13	31	Hamann et al. 2015b
2013-14	31	Hamann et al. 2015b
2014-15	13	This report

If rainfall is the primary variable contributing to improved nesting success as supported by this breeding seasons outcome it will be important to record rainfall over the breeding season (nesting and hatchling surveys) to assist in identifying this potential correlation and improving our understanding of the rookery.

Six clutches were recorded as being disturbed during the hatchling survey period: two were exposed as a result of erosion near the shoreline, three were disturbed by nesting turtles and one was predated on by a goanna. It is noted that goannas were frequently observed digging up or foraging

on old (hatched) clutches not predating on incubating clutches during the survey period on the nesting beach.

Nesting Effort Snapshot was also recorded for Giar (entire nesting beach) at 21:00 on the 18th, 22nd and 23rd November, 2014.

Table 5: Total nesting effort snapshot count (21:00) at Dauar, including respective tides, the average and SD.

Date	Start Time (24hr)	High Tide		Low Tide		Total Nesting Effort Snapshot Count
		Time (24hr)	Height (m)	Time (24hr)	Height (m)	
18/11/2014	21:00	18:53	2.4	1:16	0.9	41
22/11/2014	21:00	21:01	2.4	3:16	0.6	78
23/11/2014	21:00	21:43	2.4	3:56	0.7	60
					Average	59.67
					SD	18.50

This data by itself has limited application. The method is completed in the event that nesting turtle densities in a future breeding season are too large to record for the entire rookery using other methods (e.g. nesting effort and success). This simple method can be completed with any density present.

5.3 Tagging: Capture-Mark-Recapture

Tagging and checking for tagged recaptures of nesting green turtles took place at Giar over the six nights of the survey from the 18th - 23rd November in conjunction with other survey methods.

In total, 111 nesting female green turtles were tagged over the survey period; of the total captured 3.6% (4) were recaptures that were not tagged during the 2014-15 survey period. The curved carapace length (CCL) of each nesting turtle was measured to the nearest millimetre using a 1.5m flexible fibreglass measuring tape. The average CCL recorded was 104.1cm (range 90.9-120.7, SD 4.82, n=111). In comparison to CCL recorded in previous surveys since 2006 (2006-2013 data from Hamann, M., et al. 2015b) there has not been a significant change in average CCL since 2006 (Figure 8, R^2=0.0086).

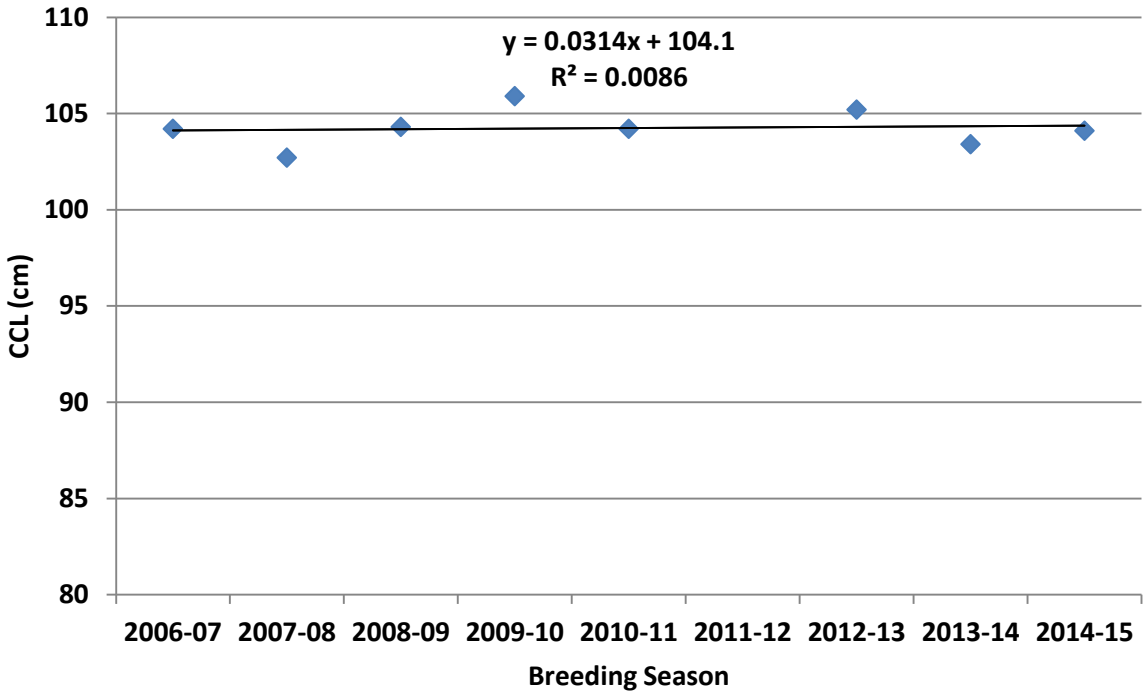


Figure 8: Average CCL of nesting green turtles at Dauar over surveyed breeding seasons, from 2006 to 2014 (excluding 2011-12 breeding season), with linear regression analysis (2007-08 n=10, 2009-10 n=57, 2010-11 n=162, 2012-13 n=6, 2013-14 n=152, 2014-15 n=111).

Using the available raw data from the 2013-14 (Hamann *et al.* 2015b) and 2014-15, the recorded CCL were placed into 5cm increment size classes in order to identify changes in size frequencies present on the rookery (Figure 9).

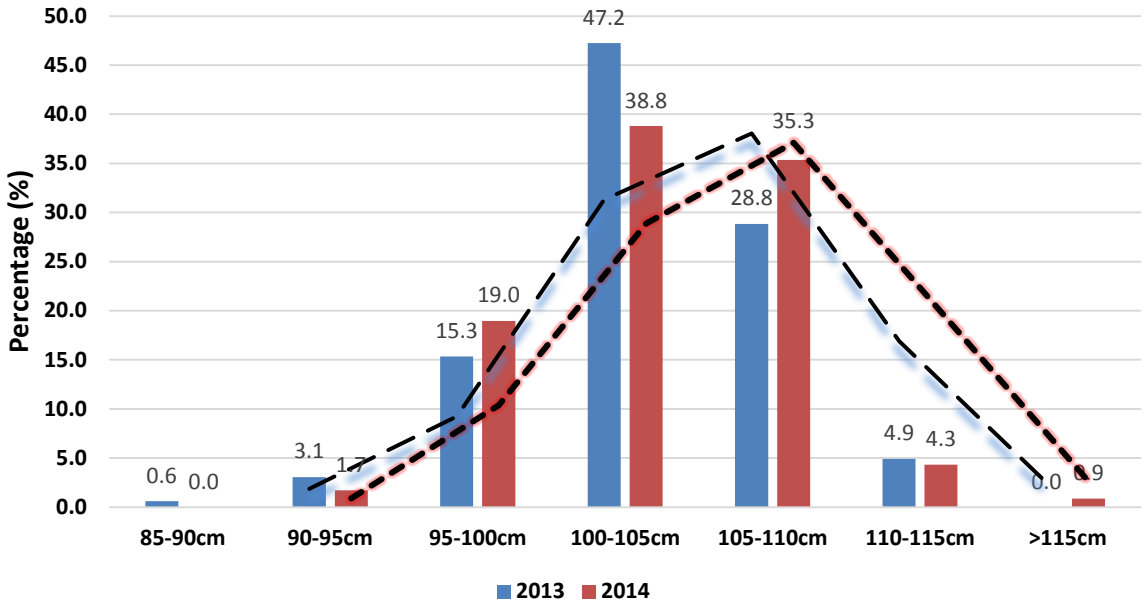


Figure 9: CCL percentage size class frequency of sampled nesting green turtles at Dauar (5cm increments) during the 2013-14 and 2014-15 breeding season showing a two period moving averages trendline.

Analysis on a two year population sample data set wouldn't garner any significant trends; however, after successive years of data collection (e.g. greater than 5 years) to cover the unknown remigration interval for the nesting green turtles of the Torres Strait (Limpus e*t al.* 2001), trends in size class changes may be recognised and give an indication of mature female population demographic changes.

5.4 Hatching Success

The completion of the Hatching Success method required that clutches be marked and recorded during the nesting survey. As already presented, nesting success was low, with a recorded average of 9.33 (range 7-12, SD 2.05, n=3) clutches laid per night in the surveyed section of Giar (Figure 7). Consequently, there were not a large number of clutches to mark and record. Over the survey period, from the 19th - 23rd November 2014, the survey team managed to observe, mark and record 38 clutches on Giar. The latitude and longitude of each clutch was recorded (hand held GPS) and marked using a 1.5m piece of bamboo that had been spray-painted pink at one end to assist in re-locating during the hatching surveys. Nest location coordinates were also recorded (hand held GPS) on Tig when undertaking the Morning After Track and Nest Count method, although these nests were not marked for excavation as the exact clutch location was not observed. The distribution of marked clutches can be seen in Figure 10.

Figure 10: Distribution of green turtle nests on Giar and Tig, Dauar for the survey period.

After a period of 72 days, the survey team returned to Dauar on the 4th February 2015 to complete the hatchling surveys. Of the 38 marked clutches, only one bamboo marker pole remained intact. All other marker poles were absent, scattered or in pieces. To demonstrate the accuracy of the recorded GPS coordinates, the waypoint for the only remaining marker placed the nest 1.6m away from the actual location. Regardless of this inaccuracy, the survey team attempted to relocate each of the clutches through the recorded nests' waypoints. Despite this limitation, the survey team

managed to excavate 42% (16) of the marked clutches, which were identified from clutch tags that were placed into the chamber when laid. The remaining 58% of clutches were not found and their respective outcomes only assumed as a potential result of the GPS inaccuracy. Therefore, statistical analysis of the located clutches is biased towards a positive hatching success as we cannot say with any certainty that the un-located clutches were disturbed or hatched.

Hatching success for the excavated clutches averaged 71.43% (range 0-97.47%, SD 29.65, n=16). One clutches waypoint was found to be located in knee deep water as a result of shifting sand between the survey periods, south easterly trade winds occur until approximately December when they change to north westerly trade winds, accounting for the single 0% hatching success recorded.

The contents of the eggs that did not survive incubation were examined. The majority (55.6%) of excavated eggs showed no visual signs of embryonic development; died within the first week (55.9%) showing no embryonic development, followed by 25.5% that showed visually identifiable sign of development, including body form, scales, and scutes. Although the recorded average of 71.43% hatching success indicates a significantly positive incubating clutch survivorship for the nesting beach there needs to be improvement in the marking and relocating of clutches between the nesting and hatchling survey periods. Considering that this is the first time that hatching success has been recorded at Dauar there is no previous data set to compare this outcome to. As a priority before the next breeding season we need to remove the limitation of in-accurate clutch location recordings to obtain a representative and accurate record of hatching success.

5.5 Hatchling Production

Three full nights (18:30 – 06:30) of hatchling production methodology were undertaken from the 5th - 7th February, 2015. The method involved digging two measured 100m trenches in the sand parallel to the shoreline at representative locations along the northern nesting beach, Giar. The trenches captured hatchlings, which were counted and recorded against the respective hourly period, then immediately released. Unfortunately the waypoints for the trench locations were lost when the vessel sank off Warul Kawa. The estimated locations of the trenches are shown in Figure 11.

Figure 11: Giar, northern nesting beach of Dauar, showing the approximate locations of the 100m hatchling productivity trenches (orange lines) as well as recorded nest distribution (red dots).

The average number of hatchlings captured each night, for both trenches, was 471.33 (range 245-893, SD 365.5, n=3). The highest number of hatchlings was recorded on the third night, which was over three times that recorded on the other two nights of monitoring. Hatchlings emerged throughout the night, with 50% emerging between 22:30 – 23:30, 75% between 01:30-02:30, and 90% between 02:30-03:30.

The average hatchling production per 100 metres of rookery shoreline per night was 250.94 (range 139.5-448, SD 171.14, n=3). This average can be compared between seasons and to other rookeries, including Maizab Kaur and Raine Island; however, as each rookery is of a different size, and nesting effort and the number of successful clutches laid can influence hatchling production, each variable needs to be standardised to represent 100m of nesting beach shoreline. The average nesting effort per 100m of shoreline recorded from the 19th to 21st of November 2014 was 15.90 (range 12.45 - 21.46, SD 4.86, n=3). The average number of successful nests per 100m of shoreline recorded from the 19th - 21st November 2014 was 2.01 (range 1.72-2.30, SD 0.29, n=3). As a ratio, this equates to 16.11 hatchlings per nesting turtle and 124.76 hatchlings per successful nest for the nesting beach Giar.

The average incubation period for green turtles has been recorded at Maizab Kaur to be 53.4 days (range 48-58 days, n= 38) during the 1977-78 breeding season (Parmenter 1978) and 56.6 (range 49-63, n=32) during the 1979-80 breeding season (Limpus e*t al.* 2001). It is noted that the hatchling survey was completed 72 days after the nesting survey, nine days longer than the largest incubation period recorded. In regard to the results this means that the calculated ratios are potentially higher than they would be if the hatchling survey was conducted closer to the recorded incubation period averages; as nesting effort and potentially nesting success are expected to have increased exponentially after the nesting survey until the peak in early January. Irrespective, the recorded hatchling production is high when compared to the number of clutches laid. Additionally, this

outcome coupled with the high hatching success, noting the improvements needed to be made to that methodology, indicate that Giar, the northern nesting beach, is a healthy rookery.

5.6 Temperature at Clutch Depth

Three temperature loggers (Thermodata DS1921G Fob Fitted Thermochron, ±0.5°C) were sealed in a clear plastic tube (waterproofing) prior to the nesting surveys and placed at nest depth (approx. 50cm) at various representative locations across Giar (Figure 12) during the nesting surveys on the 21st November 2014. The temperature loggers were pre-programmed to record the temperature every hour, starting two days after placement and were relocated and collected on the 6th February 2015.

Figure 12: Temperature logger placement at Giar, Dauar, showing photos of placement.

Of the three temperature loggers two were recovered during the hatchling surveys, D1 and D3. The third temperature logger (D2) was not found as the location where it was placed was significantly disturbed by nesting turtles and no trace of the logger or flagging tape could be found. The plotted hourly results of the temperature loggers are shown in Figure 13.

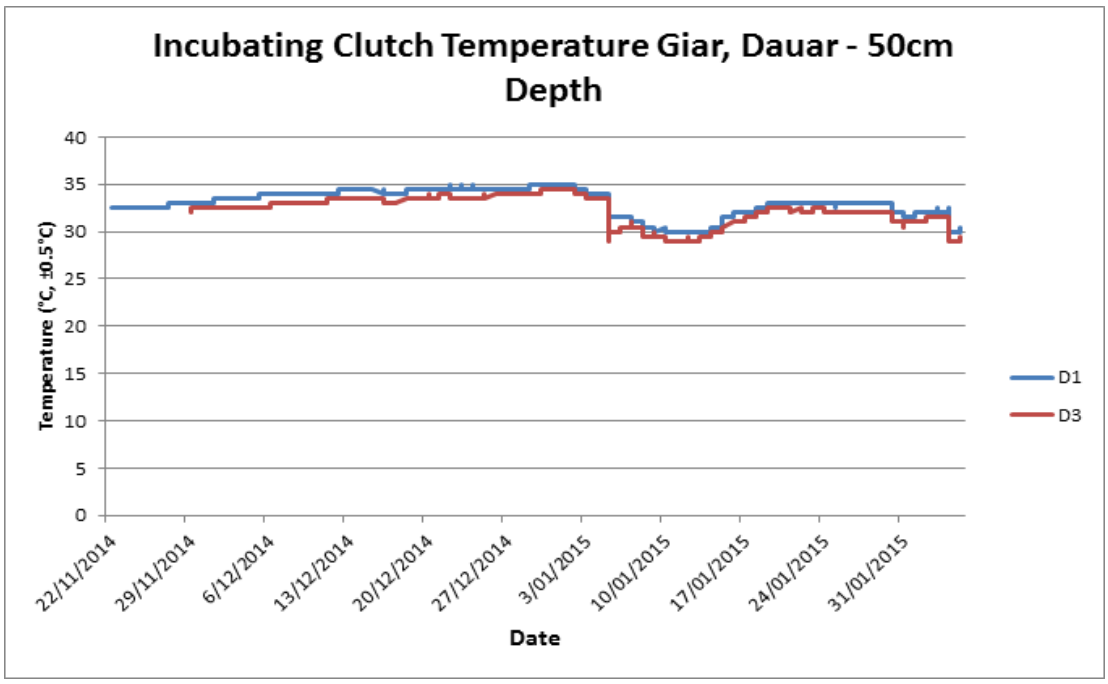


Figure 13: Plotted temperature at clutch depth (50cm) Giar, Dauar from the 23rd November 2014 - 6th February 2015.

The average temperature for logger D1 was 33.1°C (range 30-35°C, n=1799, with a recording error of ±0.5°C) while the average temperature for logger D3 was 32.3°C (range 29-34.5°C, n=1631, with a recording error of ±0.5°C). The slightly higher average temperature at site D1 (0.8°C) compared to D3 may be accounted to the lack of ground covering vegetation that is present at site D3, providing some protection from the radiant heat of the sun.

Temperature during incubation plays an important role in sex determination of marine turtles. The pivotal temperature for the northern Great Barrier Reef green turtle population is 29.3°C (Limpus e*t al.* 2003), which is the temperature that produces an even ratio of males to females for the incubating clutch. The recorded average temperatures are 3.8°C (D1) and 3.0°C (D3) higher than the pivotal temperature, indicating that the hatchlings produced at Giar, Dauar would be predominantly females.

5.7 Marine Turtle Rescue and Mortality

Upon arrival to the rookery and each morning of the survey the entire rookery was searched for stranded green turtles in need of assistance (rescued) and dead green turtles in conjunction with other methods. No marine turtles were in need of assistance during the 2014-15 breeding season. One dead green turtle was reported by a community member on the southern end of Giar where small rocky cliffs dominate the area. A search was conducted but the dead green turtle could not be found.

In the previous breeding season (2013-14) two green turtles were found dead upon arrival and four green turtles were found in need of assistance on Giar during the survey period; they had flipped themselves on some rocky outcroppings near the vegetation line on the northern end of Giar.

Although strandings do not seem to be a significant issue at Dauar the survey team will still patrol the rookery each morning to assist any green turtles in need back to the water.

6. Maizab Kaur Survey Outcomes and Discussion

Nesting green turtle surveys were undertaken at Maizab Kaur from the 1st - 9th December 2014. Hatchling green turtle surveys were undertaken at Maizab Kaur 62 days after the nesting surveys, from the 9th - 13th February 2015. As with the Dauar surveys, each of the survey participants were provided with training that included a detailed training document and presentation explaining the monitoring schedule and methods that was derived from the content of the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* document. During the nesting survey the first night of the survey was dedicated to practical training of each of the methods, which was followed by six nights of survey to complete the objectives. During hatchling surveys practical training was provided at the start of each different activity. This was satisfactory as there were a reduced number of methods and the methodology simpler. Additionally, participants with previous experience were paired with participants with no or limited experience. VHF radios were used so that if any questions or concerns surfaced during the survey they could be answered by the project leader.

6.1 Traditional Owner Collaboration

Nesting Survey
Prior to beginning of the nesting survey formal written approval was obtained from the Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC to undertake the surveys.

Tristan Simpson and Boggo Gela (Erub Senior Ranger) met with the entire Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC briefly during a board meeting to discuss the project and intended activities, as well as discuss previous outcomes before departing to Maizab Kaur to undertake the surveys. Formal permission was granted to undertake the project.

Two volunteers from Erub (Darnley Island) participated in the survey and were trained in the methodology, including Wallace Gela and Lieu (Noel) Anson.

The survey team, which included representatives from the TSRA, JCU and the Australian Institute of Marine Science (AIMS) presented the outcomes of the survey trip to the Erub community, including the Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC, Elders, and interested community members. In total approximately 30 community members were present at the public meeting. The community update was very well received and there was a keen interest in the project and the outcomes. The main points to take from the meeting were:

- They greatly appreciated direct and immediate feedback, which they said had never happened before;
- That Maizab Kaur is more than just about nesting marine turtles and has a strong cultural significance to the Traditional Owners; and
- That sea birds should be surveyed as they are also culturally important.

It is noted that sea bird surveys had been undertaken during the surveys, which was relayed to community members in the meeting. The surveys are primarily observational notes with estimates of abundances and stages. Estimates as Maizab Kaur supports a dense sea bird population that is difficult to accurately count. The observations will be presented in a subsequent section and will continue to be undertaken in conjunction with marine turtle surveys.

Hatchling Survey
Prior to beginning of the hatchling survey formal written approval was obtained from the Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC to undertake the surveys.

Tristan Simpson and Boggo Gela briefly met with Jimmy Gela, Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC Chair, before the start of the survey in order to discuss the project and obtain formal approval to visit and survey on Maizab Kaur.

Two volunteers from Erub (Darnley Island) participated in the survey and were trained in the methodology, including Barry Pau and Charles Thaiday.

The survey team, including TSRA and JCU representatives met with Erubam Le Traditional Land and Sea Owners (TSI) Corporation RNTBC and Maizab Kaur Traditional Owners to discuss all the outcomes of the project.

6.2 Nesting Effort and Success

Three full nights of nesting effort and success surveys were completed at Maizab Kaur from 18:30 to 06:30 on the 2nd - 4th December, 2014. The entire rookery was monitored over these periods by having three survey teams of two participants present on the rookery from 18:30 to 00:30 during the peak nesting period coinciding with a high tide peak in the early evening and two survey teams of two participants present on the rookery from 00:30-06:30.

The average nesting effort recorded for the survey period at Maizab Kaur was 262.00 (range 83-400, SD 162.43, n=3). At the conclusion of two survey periods, 2nd December 2014 and 3rd December 2015, there were one and two green turtles still nesting, respectively. Nesting success was not observed for these green turtles and they were not included in the nesting success calculations.

Using the cumulative arrival and departure of nesting female green turtles at Maizab Kaur, 1979-80 breeding season table (Limpus, C.J., e*t al.* 2001), the survey period was conducted during the arrival period where approximately 49.49%-64.05% of breeding female turtles would have arrived. As with the Dauar survey outcomes, using these very approximate figures and the highest nesting effort recorded, as a minimum number present, the total nesting effort during the peak of the season in late December, early January could have reached as high as 624.51 (64.05% value) – 808.24 (49.49% value).

Unlike Dauar, there has been considerable nesting effort data collected for Maizab Kaur (Table 6).

Table 6: Breeding season records available for nesting effort at Maizab Kaur from 1975 to 2015

Breeding Season	Date	Nesting Effort	Source
1975-76	7 November	1	Kowarsky (1978)
	14 December	3	
	3 January	9	
	4 January	4	
	5 January	5	
1979-80	Average commencing 16 December for 31 days	42.6 Range 19-101, SD 16.8, n=31	Limpus *et al.* (2001)
1987-88	3 January	340 Stated as potential overestimate	Walker 1988
	4 January	290	
1988-89	16 January	272	Limpus *et al.* (2003)
	17 January	140	

Breeding Season	Date	Nesting Effort	Source
1994-95	17 February	20	Ellison (1998)
	19 February	24	
2007-08	Unknown	20	Hamann e*t al.* (2015b)
2008-09	3 December	34	Hamann e*t al.* (2015b)
2009-10	9 December	35	Hamann e*t al.* (2015b)
	10 December	34	
2010-11	3 December	16	Hamann e*t al.* (2015b)
2012-13	5 December	28	Hamann e*t al.* (2015b)
2014-15	2 December	83	This report
	3 December	400	
	4 December	303	
	9 February	121	

The 2014-15 breeding season is the highest nesting effort on record for Maizab Kaur. Although, it is estimated that the highest night's nesting effort at Maizab Kaur during the 2013-14 nesting season at the same period (start of December) was approximately 600-800 nesting green turtles (Tristan Simpson, personal comment). Track counts were attempted in the mornings of the 2013-14 breeding season; however, they were incredibly inaccurate given the high nightly nesting densities and are not listed in the above table.

Even though the current seasons nesting effort is the highest recorded to date, which is a good outcome, there are many gaps within the data set where entire seasons have not been recorded. It is also known that there are inter-annual fluctuations in breeding numbers of the northern GBR green turtle population, which is the result of fluctuations in the proportion of adult females that are prepared to breed in a particular year (Limpus & Nicholls, 2000). Limpus and Nicholls (2000) found that there is a significant correlation between very high nesting records two years following an El Niño event for the northern GBR green turtle population, while two years following a La Niña event results in extremely low nesting numbers. Consequently, the results do not demonstrate a positive trend in the northern GBR green turtle population as there are too many unknown variables. Monitoring of successive breeding seasons as well as consistency in methods, including survey periods, are needed in conjunction with a continued and potentially increased tagging output during surveys to improve our understanding of the nesting female green turtle population trends.

Nesting success averaged 26.44% (range 21.36-32.34%, SD 4.52, n=3) at Maizab Kaur over the December survey period. As with Dauar, the primary observed reason for the low nesting success was dry sand causing continued collapsing of the nest during chambering (anecdotal, not quantified). It was hypothesised that nesting success would increase with increased rain during the wet season of the Torres Strait, which would improve sand integrity during nesting, in particular chambering.

One full night of nesting effort and success (18:30-06:30) was undertaken on the first night of survey Monday the 9th February 2015 to assess if nesting success had improved with the change of seasons, in particular with rainfall. The recoded nesting effort was 121 with 40 clutches laid giving a nesting success of 35.1%. As only one nesting effort and success survey was conducted statistical comparison between the two outcomes cannot be completed; however, nesting success only increased by 8.66% compared to the December average and was only 2.76% higher than the highest recorded nesting success percentage in December 2014. In comparison to the outcome at Dauar for the same season which recorded an increase in nesting success from 28.6% to 80.8%. It was still visually obvious that the sand was very dry and nesting turtles struggled to construct egg chambers that held. It is noted that rainfall increased over the survey period after the survey on the 9th February and sand was noticeably saturated, although nesting effort and success were not recorded on the remaining survey nights as hatchlings were the priority for the hatchling survey and both

could not be undertaken at the same time. In discussion with Erub community members post hatchling surveys it was confirmed that little rain had fallen in the region during this wet season.

As with Dauar, nesting success has been variable at Maizab Kaur since it was first surveyed in the 1975-76 breeding season (Table 7).

Table 7: Average nesting success at Maizab Kaur during November and December (pre wet season) for breeding seasons surveyed, also showing total observations recorded.

Breeding Season	Average Nesting Success (%)	Source
1975-76	42 (n=19)	Kowarsky (1978)
1979-80	85.5 (n=4,362)	Limpus *et al.* (2001)
2007-08	60 (n=20)	Hamann *et al.* (2015b)
2008-09	53 (n=34)	Hamann *et al.* (2015b)
2009-10	67 (n=69)	Hamann *et al.* (2015b)
2010-11	44 (n=16)	Hamann *et al.* (2015b)
2012-13	32 (n=28)	Hamann *et al.* (2015b)
2014-15	26 (n=783)	This report

It was visually obvious the nesting success was low this breeding season as a result of dry sand; although there is no data to support this statement. The Australian Institute of Marine Science (AIMS) in collaboration with the TSRA installed a real-time weather station at Maizab Kaur during the December 2014 nesting survey. One of the many environmental parameters that the station will record is rainfall (mm). The weather station is presently incomplete due to unforeseen issues and will be finished this year prior to the 2015-16 breeding season. It is anticipated that rainfall measurements will be able to be correlated against nesting success to mathematically support this hypothesis.

The average number of viable clutches disturbed per survey night was 6.67 (range 1-13, SD 6.03, n=3). As a percentage of clutches disturbed to new clutches laid the average percentage 8.36% (range 4.76-13.27%, SD 4.40, n=3), meaning that during the survey period more clutches were being laid than disturbed. As a percentage of clutches disturbed to nesting effort per night the average percentage was 2.33% (range 1.20-4.29%, SD 1.70, n=3). These percentages can be compared between seasons to identify how clutch disturbance changes with varying nightly nesting success and nesting effort.

A Nesting Effort Snapshot was recorded for Maizab Kaur at 21:00 on the 1st, 5th, 6th and 7th December 2014.

Table 8: Nesting effort snapshot count (21:00) at Maizab Kaur, including respective tides, the average and SD.

Date	Start Time (24hr)	High Tide		Low Tide		Total Nesting Effort Snapshot Count
		Time (24hr)	Height (m)	Time (24hr)	Height (m)	
1/12/2014	21:00			1:07	0.4	87
5/12/2014	20:57	20:56	2.4	3:22	0.2	199
6/12/2014	21:03	21:32	2.3	3:51	0.3	184
7/12/2014	21:11	22:09	2.2	4:20	0.5	158
					Average	157
					SD	49.64

This data by itself has limited application. The method is completed in the event that nesting turtle densities in a future breeding season are too large to record for the entire rookery using other methods (e.g. nesting effort and success). This simple method can be completed with any density present.

6.3 Tagging: Capture-Mark-Recapture

Tagging and checking for tagged recaptures of nesting green turtles took place at Maizab Kaur over the seven nights of the survey from the 1st - 7th December in conjunction with other survey methods. In total, 211 nesting female green turtles were tagged over the survey period; of the total captured 3.79% (8) were recaptures that were not tagged during the 2014-15 survey period. The curved carapace length (CCL) of each nesting turtle was measured to the nearest millimetre using a 1.5m flexible fibreglass measuring tape. The average CCL recorded was 105.5cm (range 90.7-122.1, SD 4.37, n=211). In comparison to CCL recorded in previous surveys since 1975 (1975-76 data from Kowarsky (1978); 1979-80 data from Limpus e*t al.* (2001); and 2007-2013 data from Hamann *et al.* (2015b)) there has not been a significant change in average CCL since 1975 (Figure 14, R^2=0.1861).

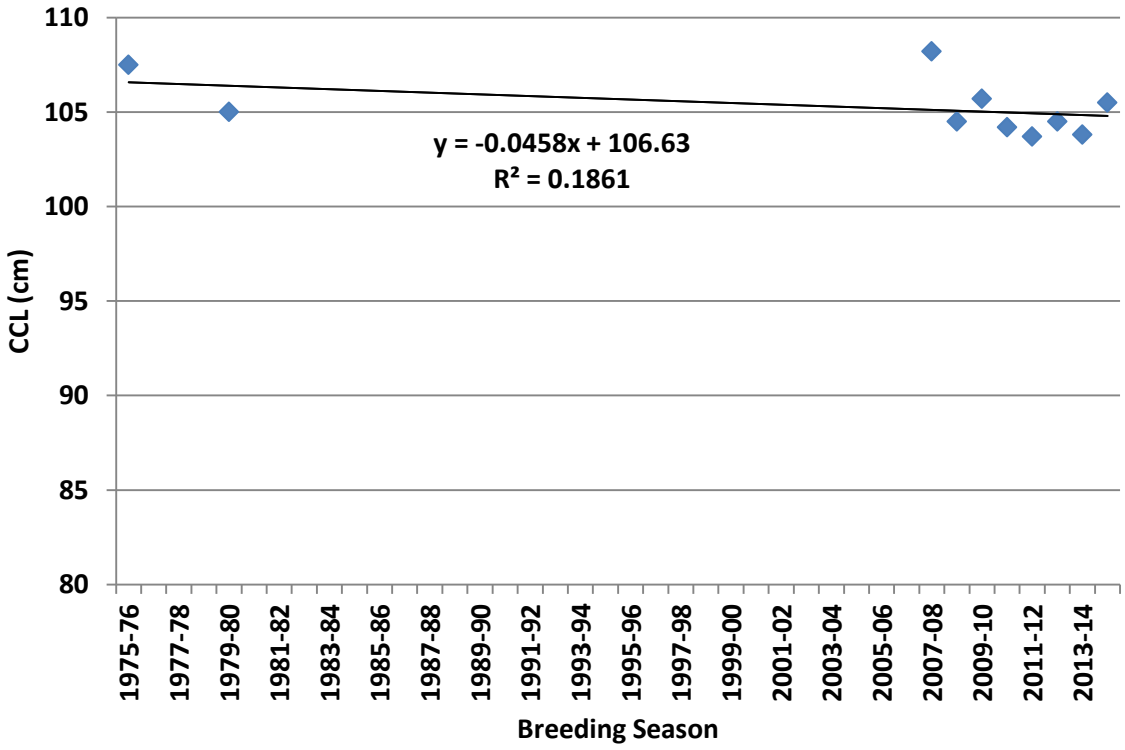


Figure 14: Average CCL of nesting green turtles at Maizab Kaur over surveyed breeding seasons, from 1975 to 2014, with linear regression analysis (1975-76 n=9; 1979-80 n=687, 2007-08 n=22, 2008-09 n=220, 2009-10 n=92, 2010-11 n=149, 2011-12 n=204, 2014-15 n=211).

Using the available raw data from the 2013-14 (Hamann et al. 2015b) and 2014-15, the recorded CCL were placed into 5cm increment size classes in order to identify changes in size frequencies present on the rookery (Figure 15).

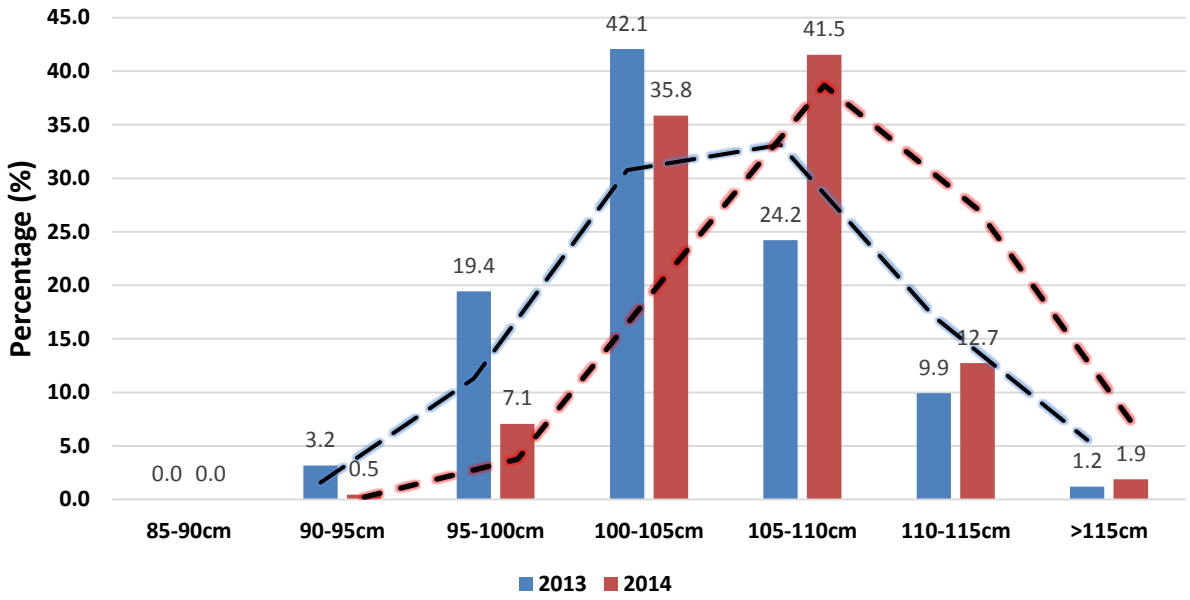


Figure 15: CCL percentage size class frequency of sampled nesting green turtles at Maizab Kaur (5cm increments) during the 2013-14 and 2014-15 breeding season showing a two period moving averages trendline.

Analysis on a two year population sample data set wouldn't garner any significant trends; however, after successive years of data collection (e.g. greater than 5 years) to cover the unknown remigration interval for the nesting green turtles of the Torres Strait (Limpus e*t al.* 2001), trends in size class changes may be recognised and give an indication of mature female population demographic changes.

6.4 Hatching Success and Island Geomorphology

Maizab Kaur is a small dynamic sandy cay that changes shape and size with the seasons. The predominant south-easterly trade winds during the dry season in the Torres Strait produce waves that to transport the island's sand in a north-westerly direction. Maizab Kaur is situated on the western edge of a fringing coral reef and there is potential that some of this sand lost into deeper water where waves cannot return it to the reef and island during the north-westerly monsoon. During the wet season strong north-westerly winds dominate, usually for a shorter period than the southeast trades. These winds generate waves that push the sand in a south-easterly direction, back onto the reef flat. The seasonal changes and approximate annual reformations are known by local community members and have been reported on by Limpus e*t al.* (2001).

Table 9: Changing dimensions of Maizab Kaur from 1977-1980 showing reduction in size between dry and wet seasons and increase in size between wet and dry seasons

Breeding Season	Date	Area (hectares)	Source
1977-78	6 October	4.67	Limpus e*t al.* (2001)
	26 February	3.26	
1978-79	15 October	4.08	
	29 March	3.06	
1979-80	22 October	4.93	
	21 March	3.31	

Although the data collected supports a seasonal reduction in size during the wet season followed by an increase in size of the island during the dry season, there have been improvements in the methodologies available to accurately record changes in island area and volume since the late 1970's. During the 2014-15 breeding season the TSRA collaborated with JCU in order to provide and operate a differential GPS Real Time Kinematic (RTK) Unit, which can accurately record within a few millimetres the latitude and longitude coordinates of a location or track and its elevation. The utilisation of the dGPS RTK Unit had two primary aims for the survey:

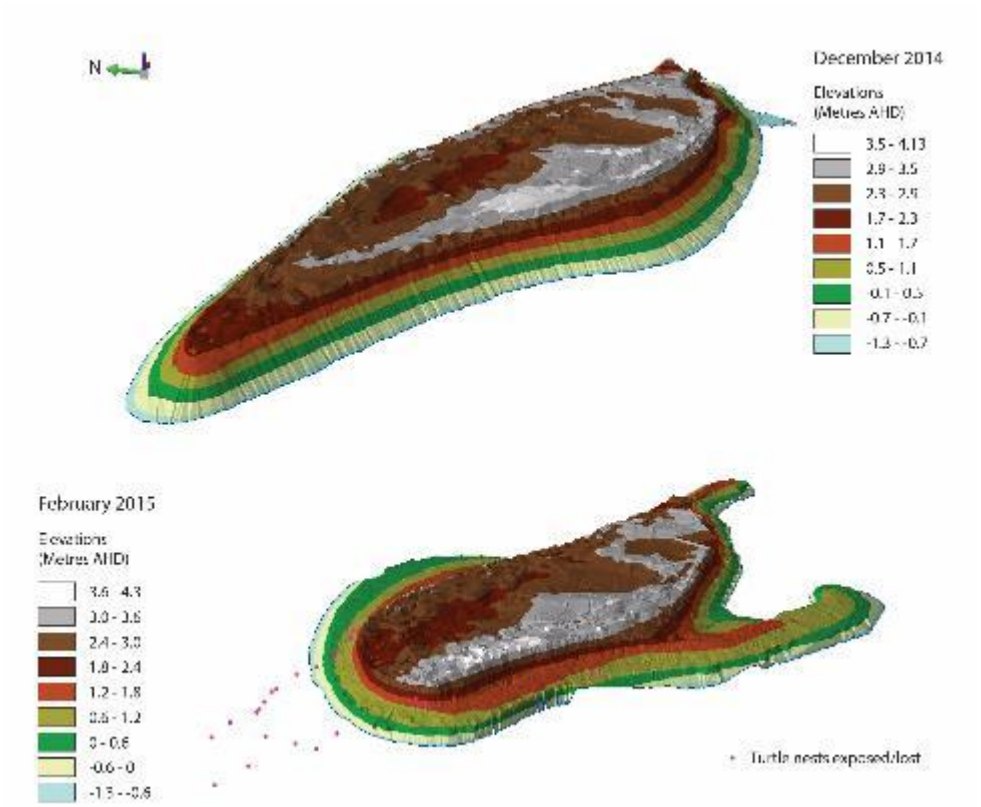
- To quantify seasonal changes in the geomorphology of Maizab Kaur; and
- To identify any impacts or threats to the rookery, nesting green turtles or incubating clutches based on the recorded geomorphological changes.

Scott Smithers and John Dawson from the College of Marine and Environmental Sciences at JCU participated in the nesting and hatchling surveys at Maizab Kaur, respectively. Three permanent reference sites or benchmarks were established for the dGPS RTK Unit on the 2nd December 2014. Mapping of the island was undertaken during the day for the remainder of the survey, from the 3rd - 7th December 2014, which involved walking over as much of the island as possible with the geo-referenced dGPS RTK Unit (Figure 16).

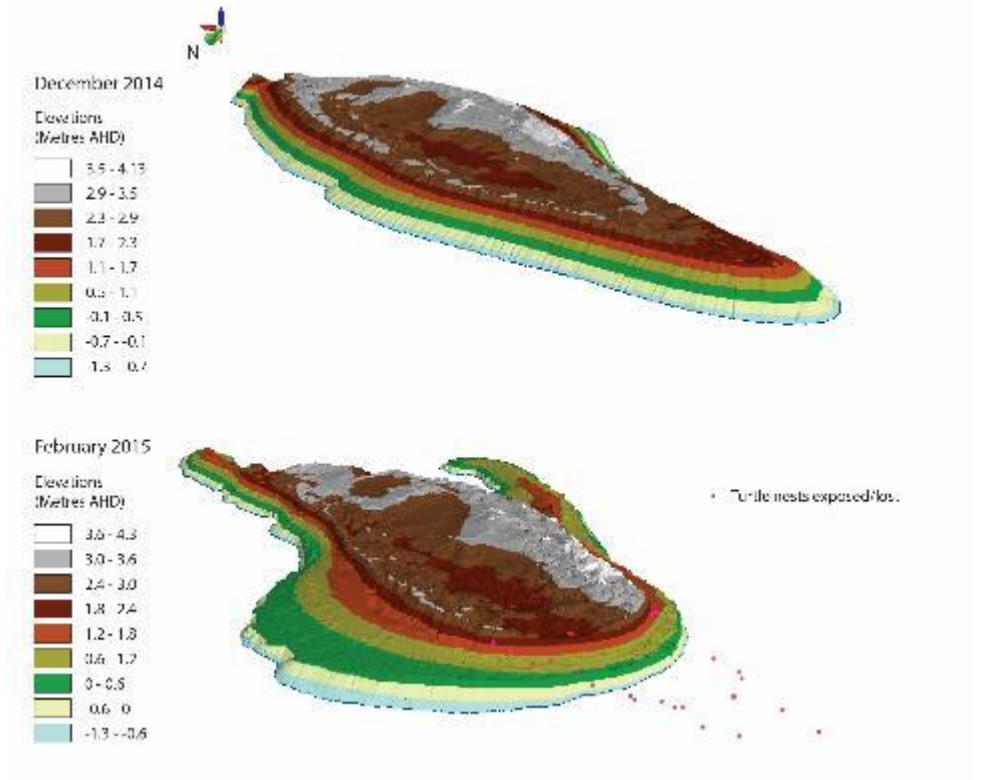
Figure 16: Mapping of Maizab Kaur with the dGPS RTK Unit during the nesting surveys in December, 2014

The dGPS RTK Unit was also used to mark and record observed nests over the nesting survey period from the 5th - 7th December, 2014. To ensure that recorded clutches were representative of the rookery each survey night focused on a different area of the rookery. The dGPS RTK Unit was used instead of marking clutches with stakes because of the high nesting density at Maizab Kaur, which would certainly disturb or destroy any clutch markers. In total 84 successful nests were observed and recorded during the survey period. Clutch tags were placed in with the incubating eggs (a small piece of pink flagging tape with the unique clutch number and date recorded on it).

After a period of 62 days, the survey team returned to Maizab Kaur on the 9th February 2015 to complete the hatchling surveys. Mapping of the rookery using the dGPS RTK Unit also occurred during the hatchling surveys from the 10th - 12th February, 2015. There was a significant change in the shape, area and volume of Maizab Kaur between the two survey periods (Figure 17).



a)



b)

Figure 17: Digital Elevation Models of Maizab Kaur recorded in December 2014 and February 2015 from a) a western angle; and b) a northern angle, showing exposed/destroyed recorded clutches as a result of the sand movement (Source: College of Marine and Environmental Sciences JCU)

Figure 18 shows a two dimensional outline of the recorded high-tide lines in December 2014 and February 2015 over geo-referenced satellite imagery, as well as the distribution of successful nests recorded during the nesting surveys, which were primarily laid around the berm of the island.

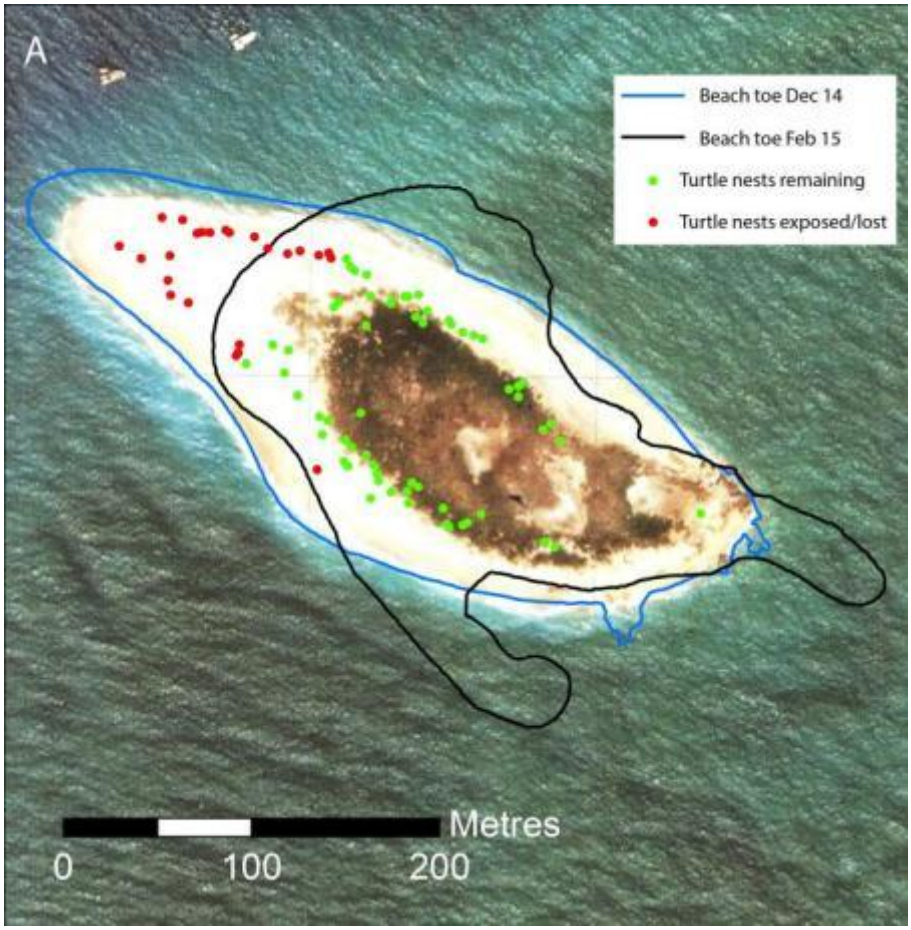


Figure 18: dGPS surveys of the toe of beach overlaid onto a geo-referenced Quickbird satellite image from 2006 - Green points represent successful nests marked in December 2014 and rediscovered in February 2015 while red points indicate successful nests that were lost due to seasonal sand movement (Source: College of Marine and Environmental Sciences JCU)

The largest portion of sand displaced was from the north-western point of the island (-23,008m^3), some of which has been displaced onto the reef flat and some redistributed to other areas of the island, forming two large sand spits off the southern (+6,969m^3) and eastern (3,665m^3) shorelines of the island (Figure 19).

However, overall a net loss in area and volume has been recorded for the island (Figure 19). The area of the island, as a two dimensional aerial calculation, decreased by 7.1% between December 2014 and February 2015. The volume of the island, as a three dimensional calculation that accounts for elevation, decreased by 12.4% between December 2014 and February 2015.

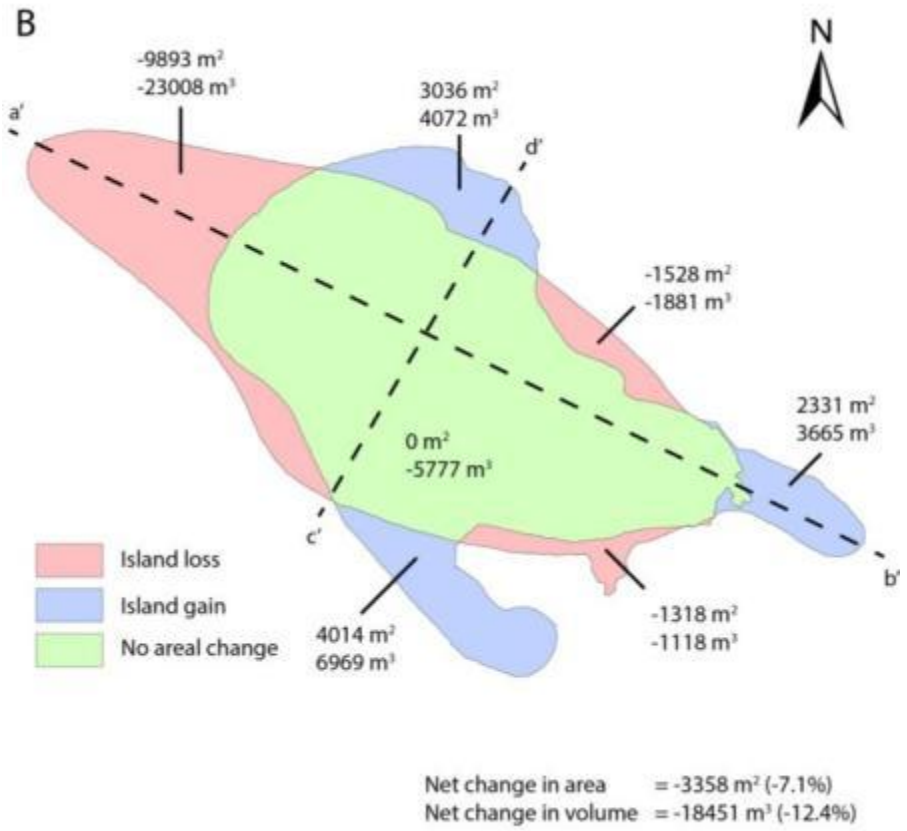


Figure 19: Spatial changes in island area (m^2) and volume (m^3) across the island between December 2014 and February 2015 including calculated total net changes (Source: College of Marine and Environmental Sciences JCU)

The cross-sectional profiles a-b and c-d shown in Figure 19 are displayed in Figure 20. They show that the central portion of the island has remained stable. Unfortunately much of the central portion is not viable for green turtle nesting due to the presence of vegetation, phosphate rock and nesting sea birds.

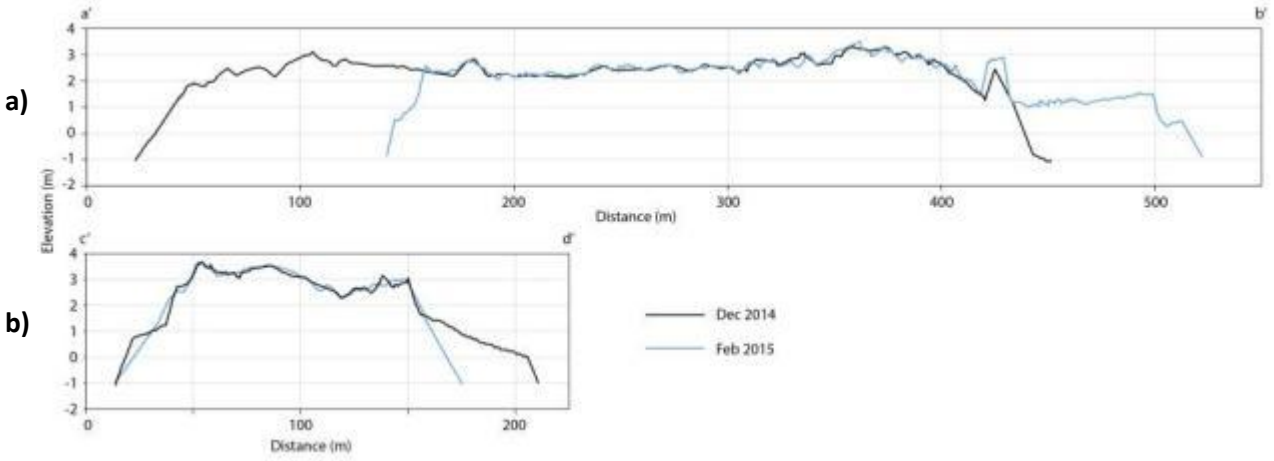


Figure 20: Cross-sectional profiles of Maizab Kaur from December 2014 and February 2015, showing a) from a to b; and b) from c to d (in Figure 19) (Source: College of Marine and Environmental Sciences JCU)

The highly dynamic changes recorded at Maizab Kaur over a short two-month period from December 2014 to February 2015 are logical given that the island is situated on the western edge of a fringing coral reef that is adjacent to deep water and is fully exposed to the strong north-westerly storms and its wind driven swell. Contrastingly the island is well protected by a large shallow reef flat to the east of the island that is thought to dissipate swells generated by the south-easterly trade winds.

It is important to note that this is an outcome from one change in season's survey using this highly precise methodology. It has already been established that Maizab Kaur reduces in size over the green turtle breeding season, reattaining variable area prior to the next breeding season. However, there are still unknown factors that may contribute to the long-term sustainability of Maizab Kaur, including:

- The frequency and intensity of the north-westerly storms and south-easterly trade winds each year: although unrecorded, the changes observed between December 2013 and March 2014 were less radical (Tristan Simpson Senior NRM Officer (Sea), pers. comm.), for example there was no visible sand spit off the eastern point of Maizab Kaur indicating less severe north-westerly weather;
- The primary cause of sand displacement of the island is unknown, whether wind, swell, current, tide or a combination of all;
- The settlement location and volume of displaced sand during both the dry and wet seasons, including identifying how much of the displaced sand will not be reattained by the island during the dry season; and
- The recruitment rate of new sand formed by forams (*Baculogypsina sphaerulata*) which is the dominant component of Maizab Kaur (Figure 21).

Figure 21: Dominant component of Maizab Kaur, the forminifera, *Baculogypsina sphaerulata*, with some coral rubble

In order to accurately ascertain whether or not Maizab Kaur has a cumulative sand deficit this methodology needs to be repeated over successive breeding seasons during both the nesting and hatching surveys and the outcomes compared.

Of the 84 marked clutches 57 of the clutches were re-marked for excavation. A malfunction in the dGPS RTK Unit on the last day of survey prevented the remaining 27 clutches from being re-marked for excavation. The displaced sand had a significant impact on incubating clutches that were laid during the December 2014 nesting surveys. Figure 18 shows that 24 of the 84 (28.6%) recorded

clutches were destroyed as a result of the seasonal movement of sand; this outcome alone greatly brings down hatching success for the recorded incubating clutches. Clutch loss as a result of erosion and flooding has been recorded previously (Table 10).

Table 10: Recorded clutch loss as a result of erosion or flooding at Maizab Kaur from 1977 to 2014 breeding seasons

Breeding Season	Clutch Loss (%)	Source
1977-78	42.7	Parmenter (1978)
1978-79	44.1	Parmenter (1979)
1979-80	33.5 (approximate)	Limpus e*t al.* (2001)
2014-15	28.6	This report

As with the recorded sand movement, this outcome has been occurring at Maizab Kaur at least since 1975 and its actual impact on the northern GBR green turtle population is unknown. What is known is that the nesting female population present at Maizab Kaur during the 2014-15 breeding season is the largest recorded for the rookery, which indicates that the mature female demographic has not decreased; however, as stated in section 6.2 there are several unknown variables that need to be identified through further monitoring of the rookery's mature female population over successive years to improve our understanding of the nesting female green turtle population trends.

The remaining 33 of 57 clutches were re-marked using the dGPS RTK unit for excavation:

- 8 clutches (14% of the total 57 re-marked) were found and able to be assessed (greater than 40 eggs found, see methodology document);
- 4 clutches (7%) with less than 40 eggs were found, meaning the clutch has been disturbed, however, each of the four clutches had a majority of hatched shells indicating that potentially the clutch was disturbed after hatching, therefore these clutch will be excluded from the hatching success calculations;
- 1 clutch (1.8%) excavation encountered numerous live hatchlings making their way to the surface at approximately 35cm depth and further excavation was abandoned and the nest recovered – a period of 65 days since the clutch was laid and recorded, the average incubation period for Maizab Kaur has been recorded at Maizab Kaur as 53.4 days (range 48-58, SD 4.0, n=38, Parmenter (1978)) and 56.6 days (range 49-63, n=32, Limpus e*t al.* (2001)), meaning there is a chance it could be the recorded clutch as it is only two days greater than the highest incubation period recorded, however, there is also a chance that the original clutch was disturbed and a new clutch laid within a week after being laid, therefore this clutch will be excluded from the hatching success calculations;
- 4 clutch (7%) excavations encountered fresh incubating eggs meaning the original clutch had been disturbed;
- 16 clutches (28.1%) could not be found and were assumed to be disturbed by nesting female turtles – the average change in elevation over the marked clutches was ±18.69cm (range ±0.34-56.93cm, SD 11.73. n=60), typically nests were attempted to be excavated to the extent of reach of the survey participants, several excavation depths were measured and ranged between 90-115cm, meaning if the eggs were there they would have been found (Figure 22).

Figure 22: TSRA survey participants, Rangers Aaron Bon and Ted Whap attempting to excavate a clutch at Maizab Kaur, February 2015

The hatching success for the excavated clutches was low, with a recorded average of 9.83% (range 0-85.51%, SD 24.4, n=52). Of the 52 hatching success results included in the average, 44 were recorded as 0; of the recorded clutch outcomes 46.15% attributed to sand displacement and 38.46% presumed by nesting green turtles. This result is biased towards a lower percentage purely because it was easy to exclude the 24 clutches that were destroyed by the displaced sand; additionally, the remaining 27 clutches that could not be re-marked due to equipment failure could not be excavated and their hatching success determined.

Hatching success has been recorded at Maizab Kaur on two other occasions. During the 1977-78 breeding season the average emergence success was 41.0% (range 0-84%, SD 5.0, n=34; Parmenter, 1978). During the 1979-80 breeding season the average emergence success was 68.5% (range 0-99%, n=47; Limpus e*t al.* 2001). The 2014-15 hatching success and emergence success are the same as no dead hatchlings were found within the clutches excavated, and therefore the results can be compared without any calculations. The primary variance between the 2014-15 breeding season and the 1979-80 breeding season appears to be a lower nesting effort, which averaged 42.6 per night during the 1979-80 season, compared to 262 per night this season. Unfortunately, nesting effort data for the 1977-78 breeding season could not be found. This method needs to be repeated annually to compare and identify if this seasons outcome is representative of the rookery, and to clarify if the extent of sand displacement and nesting effort as significantly impact the incubating clutches as they did this breeding season.

Of the 8 clutches that were found the contents of the eggs that did not survive incubation were examined. The majority (62.8%) of the examined eggs showed no embryonic development, likely to have died during the very early stages of gestation, while 36.5% had developed significantly with visually identifiable body form, scales, and scutes. Two of the clutches excavated had some visibly intact (un-punctured) eggs (uncounted) with an unknown white fungus attached to the developing embryo (Figure 23).

Figure 23: Two of the dead eggs excavated displaying the unknown white fungus that was growing on the developing embryo at Maizab Kaur.

Considering that hatching success for the clutches excavated and found averaged 63.89% (range 25.93-85.51%, SD 19.78, n=8), and the large recorded clutch destruction as a result of sand displacement and presumably nesting green turtles, the development arrest stage outcomes are not going to be deliberated further. They do, however, warrant recording in future surveys in the event that incubating clutch concerns are raised and need to be compared to previous records.

6.5 Hatchling Production

Three full nights (18:30 – 06:30) of hatchling production methodology were undertaken from the 10th - 12th February 2015. The method involved digging two measured 75m trenches in the sand parallel to the shoreline at representative locations along the circumference of Maizab Kaur (Figure 24). The newly formed sand spits were not surveyed for obvious reasons. The trenches captured hatchlings, which were counted and recorded against the respective hourly period, then immediately released. Unfortunately the waypoints for the trench locations were lost when the vessel sank off Warul Kawa. The estimated locations of the trenches are shown in Figure 25.

Figure 24: The 75m excavated trench on the northern shoreline of Maizab Kaur February, 2015.

Figure 25: Maizab Kaur showing the approximate locations of the 75m hatchling productivity trenches (orange lines) against the February 2015 high tide line as well as recorded nest distribution (red dots – destroyed nests, green dots – viable clutches not impacted by displaced sand).

The average number of hatchlings captured each night, for both trenches, was 563.67 (range 395-709, SD 158.30, n=3). Hatchlings emerged throughout the night, with 50% emerging between 22:30 – 23:30, 75% between 00:30-01:30, and 90% between 02:30-03:30, which mirrors the Dauar outcomes and means that future surveys still need to be conducted throughout the entire night.

The average hatchling production per 100 metres of rookery shoreline per night was 375.78 (range 263.33-472.67, SD 105.53, n=3). Despite the recorded destruction of marked and excavated nests this value is still higher than the average recorded at Dauar (250.94). The recorded circumference of Maizab Kaur at high tide during the December 2014 nesting surveys was 1,024m; correspondingly the average nesting effort per 100m of shoreline was 25.59 (range 8.10-39.06.94, SD 15.86, n=3), while the average number of successful nests per 100m of shoreline recorded over the same dates was 6.64 (range 2.05-9.57, SD 4.03, n=3). As a ratio, this equates to 22.03 hatchlings per nesting turtle and 84.88 hatchlings per successful nest for Maizab Kaur. The nesting beach Giar, Dauar recorded an average of 250.94 hatchlings per 100m, 16.11hatchlings per nesting turtle and 124.76 hatchlings per successful nest. In comparison Maizab Kaur still produces more hatchlings than Dauar despite the recorded clutch destruction as a result of displaced sand and disturbance by nesting turtles, which is due to the greater number of successful nests laid (Maizab Kaur average 68.00, Dauar average 9.33); however, incubating clutch survivorship is greater at Giar, Dauar, which provides a more stable environment that promotes greater emergence success and hatchling production per clutch laid.

6.6 Temperature at Clutch Depth

Three temperature loggers (Thermodata DS1921G Fob Fitted Thermochron, ±0.5°C) were sealed in a clear plastic tube (waterproofing) prior to the nesting surveys and placed at nest depth (approx. 50cm) at various representative locations across Maizab Kaur (Figure 26) during the nesting surveys

on the 2nd and 4th December, 2014. The temperature loggers were pre-programmed to record the temperature every hour, starting two days after placement and were relocated and collected on the 10th of February, 2015.

Figure 26: Temperature logger placement at Maizab Kaur, showing photos of placement.

Of the three temperature loggers one was recovered (MK2), the others could not be found as the locations where they were placed were significantly disturbed by nesting turtles. The plotted hourly results of the temperature loggers are shown in Figure 27.

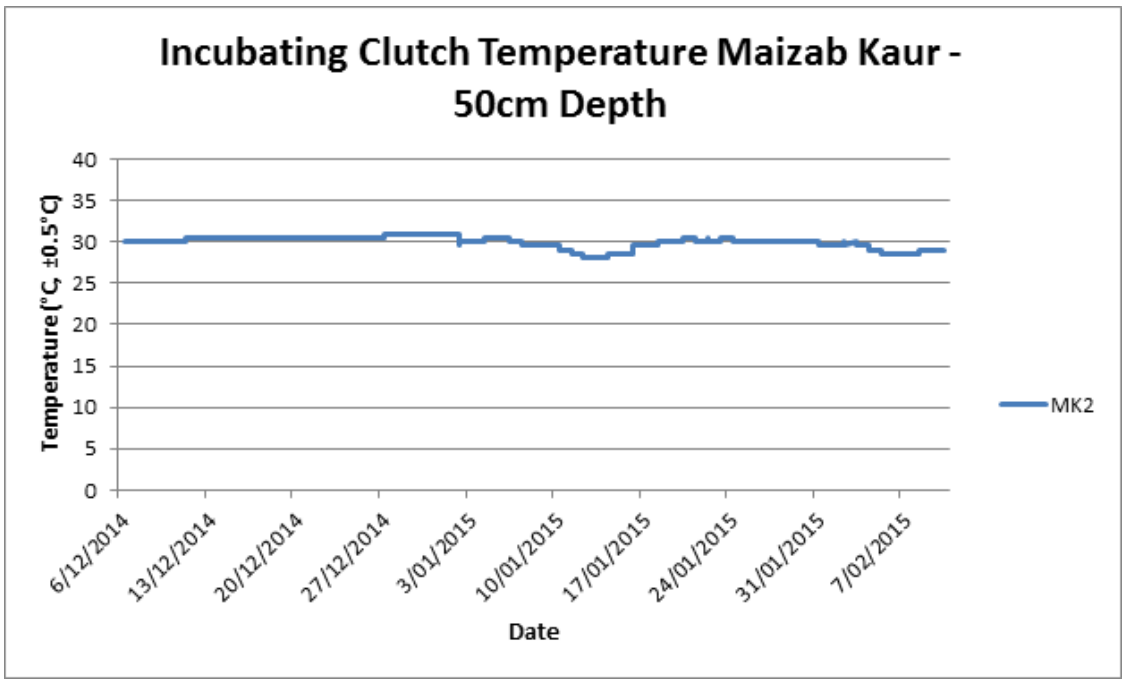


Figure 27: Plotted temperature at clutch depth (50cm) at Maizab Kaur from the 6th December 2014 - 10th February 2015.

The average temperature for logger MK2 was 29.9°C (range 28-31°C, n=1583, with a recording error of ±0.5°C). Temperature during incubation plays an important role in sex determination of marine turtles. The pivotal temperature for the northern Great Barrier Reef green turtle population is 29.3°C (Limpus e*t al.* 2003), which is the temperature that produces an even ratio of males to females for the incubating clutch. The recorded average temperature is 0.6°C higher than the pivotal temperature, indicating that the hatchlings produced at Maizab Kaur would be close to an even ratio of males to females.

Interestingly Maizab Kaur is more exposed to the sun with no elevation or shade yet the average incubating temperature was 3.2 °C and 2.2 °C less than the average temperature loggers placed at Dauar which has less exposure to the elements due to increased elevation and vegetation. Although environmental parameters were not recorded at either site, Dauar was noticeably more humid with thick ground condensation forming during the night during both nesting and hatchling surveys, while Maizab Kaur was cooler due to the exposure to prevailing winds.

6.7 Marine Turtle Rescue and Mortality

Upon arrival at Maizab Kaur and each morning of the survey the entire island was searched for stranded green turtles in need of assistance (rescued) and dead green turtles. Typically the survey team monitored the known areas while conducting other surveys where nesting green turtles were known to fall off small cliffs and become flipped or trapped; aiming to prevent the need for rescue by guiding the nesting green turtle back to the water.

On arrival at Maizab Kaur for the nesting surveys two green turtles were found dead, flipped over off the cliffs near the south-eastern end of the island (Figure 28). Both turtles were found in poor condition, one with slightly mummified flesh and the other still undergoing body cavity expansion as a result of decomposition gases.

Figure 28: Maizab Kaur showing the location of the small cliff area (blue) at the south-eastern point of the island where the two dead turtles were found on arrival on the 1st December 2014 and another small cliff area where dead nesting green turtles were found in the December 2013 nesting surveys (red).

During the nesting survey period six nesting green turtles were prevented from going over the cliffs and guided back to the water. One nesting green turtle was found flipped off the cliffs at the end of a nesting effort and success survey and was rescued and tagged before release. The marine turtle rescue and mortality was not recorded during the December 2013 nesting surveys; however, there were more dead nesting green turtles found on arrival during the 2013 survey, likely due to the higher nesting effort during the 2013-14 breeding season (Figure 29).

Figure 29: Maizab Kaur showing found dead nesting green turtles a) in the same location as those found in the December 2014 nesting surveys, and b) in the small cliff area highlighted in Figure 28 (red) that wasn't exposed during the December 2014 nesting surveys.

One green turtle was found dead on arrival for the hatchling surveys on the 9th February 2015. This turtle was found dead on the nesting beach, presumed to have died as a result of being lost and from exposure to the sun. No new dead turtles were found off the south-eastern cliff. One green turtle was rescued from the south-eastern cliff area during the first night of survey on the 9th February 2015.

Although the small phosphate rock cliffs do claim the lives of some nesting green turtles, they do not seem to pose a serious threat to the nesting female population. Recording the turtle mortalities and rescues should still continue in the event seasonal and annual erosion becomes an issue in the future.

7. 2014-15 Tag Recapture Outcomes

The TSRA LSMU Sea Team submits recaptured tagged turtle numbers and details (where possible) to the QLD DEHP to identify their respective history and to understand their migrational habits. During the 2014-15 financial year 25 tagged turtle histories were obtained, the outcomes are outlined in Table 11.

Table 11: Recaptured tagged turtles within the Torres Strait during the 2014-15 financial year turtles and their respective histories.

Tag Number	History
K32327	Adult Female Green Turtle: 1. Tagged at Raine Island 29 November 1999, Nesting, CCL 102.4cm 2. Recaptured at Raine Island 4 December 2005, Nesting, CCL 103.6cm 3. Recaptured near Warraber, unknown month 2014, behaviour and CCL
T94033	Adult Female Green Turtle: 1. Tagged at South-West Herald Cay NE of Townsville 4 December 1996, Nesting, CCL 109.4cm 2. Recaptured near Warraber, unknown month 2014, unknown behaviour and CCL
K70659	Adult Female Green Turtle: 1. Tagged at Heron Island southern GBR 31 January 2006, Nesting, CCL 104.5cm 2. Recaptured near Warraber, unknown month 2014, unknown behaviour and CCL
QA1095	Adult Female Green Turtle: 1. Tagged at Raine Island 7 December 2008, Nesting, CCL 103.6cm 2. Recaptured near Warraber, unknown month 2014, unknown behaviour and CCL
QA1274	Adult Female Green Turtle: 1. Tagged at Raine Island 5 December 2008, Nesting, CCL 103.5cm 2. Recaptured near Warraber, unknown month 2014, unknown behaviour and CCL
K33191	Adult Female Green Turtle: 1. Tagged at Raine Island 16 February 2002, Nesting, CCL 103.5cm 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
K41755	Adult Female Green Turtle: 1. Tagged at Raine Island 3 December 2001, Nesting, CCL 101.1cm 2. Recaptured at Raine Island 7 December 2008, Nesting, CCL 101.3cm 3. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
K65860	Adult Female Green Turtle: 1. Tagged at Raine Island 1 December 2004, Nesting, CCL 111.6cm 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
QA0817	Adult Female Green Turtle: 1. Tagged at Raine Island 2 December 2008, Nesting, CCL 103.6cm 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
T89954	Adult Female Green Turtle: 1. Tagged at Raine Island 7 December 1995, Nesting, CCL 104.0cm 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
T91471	Adult Female Green Turtle: 1. Tagged at Raine Island 9 December 1995, Nesting, CCL 112.4cm 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL
IDP0303	Adult Female Green Turtle: 1. Tagged at West Papua New Guinea, Unknown date, behaviour and CCL 2. Recaptured near Badu, unknown month 2014, unknown behaviour and CCL

Tag Number	History
K30606	Adult Female Green Turtle: 1. Tagged at Raine Island 6 December 1999, Nesting, CCL 107.7cm 2. Recaptured near Kings Head Horn Island 30 August 2014, Feeding, unknown CCL
CA5304	Adult Female Green Turtle: 1. Tagged at North Herald Cay NE of Townsville 14 December 2001, Nesting, CCL 109.0cm 2. Recaptured near Mua, 9 April 2015, Feeding, unknown CCL
T71726	Adult Female Green Turtle: 1. Tagged at Raine Island 3 December 1993, Nesting, Unknown CCL 2. Recaptured near Mua, 14 April 2015, Feeding, unknown CCL
K61479	Adult Female Green Turtle: 1. Tagged at Raine Island 5 December 2004, Nesting, CCL 111.6cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
K76253	Adult Female Green Turtle: 1. Tagged at Raine Island 3 December 2005, Nesting, CCL 105.1cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
K98297	Adult Female Green Turtle: 1. Tagged at No. 8 Sandbank 27 November 2008, Nesting, CCL 99.0cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
K92297	Adult Female Green Turtle: 1. Tagged at Raine Island 9 December 2007, Nesting, CCL 101.5cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
QA38407	Adult Female Green Turtle: 1. Tagged at Maizab Kaur 2 December 2013, Nesting, CCL 108.0cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
QA38411	Adult Female Green Turtle: 1. Tagged at Maizab Kaur 2 December 2013, Nesting, CCL 114.0cm 2. Recaptured near Erub (Darnley Island), unknown month 2014, behaviour and CCL
K89625	Adult Female Green Turtle: 1. Tagged at Dauar 24 November 2008, Nesting, CCL 112.0cm 2. Recaptured near Mer (Murray Island), unknown month 2014, behaviour and CCL
K63727	Adult Female Green Turtle: 1. Tagged at Maizab Kaur 18 November 2004, Nesting, Unknown CCL 2. Recaptured at Maizab Kaur 2 December 2014, Nesting, CCL 106.1cm
Left K63766 / Right QA54101	Adult Female Green Turtle: 1. Tagged at Maizab Kaur 19 November 2004, Nesting, Unknown CCL 2. Recaptured at Maizab Kaur 3 December 2014, Nesting, CCL 116.4cm
Left K19687 / Right QA54177	Adult Female Green Turtle: 1. Tagged at Maizab Kaur 19 November 2002, Nesting, Unknown CCL 2. Recaptured at Maizab Kaur 7 December 2014, Nesting, CCL 104.0cm
QA23102	Adult Female Green Turtle: 1. Tagged at Raine Island 11 March 2011, Nesting, CCL 109.9cm 2. Recaptured near Boigu, unknown date, behaviour and CCL
QA17529	Adult Female Green Turtle: 1. Tagged at Raine Island 8 December, Nesting, CCL 114.0cm 2. Recaptured near Boigu, unknown date, behaviour and CCL

Adult female green turtles that were tagged while nesting at Raine Island formed the majority of recaptured turtles in the Torres Strait (59.3%), followed by adult female green turtles that nested within the Torres Strait (22.2%), and adult female green turtles that nested at the Herald Cays QLD that is north-east of Townsville (7.4%) (Figure 30). The remaining tagged adult female green turtle

recaptures were evenly distributed (3.7%) and were tagged nesting at No. 8 Sandbank, Heron Island in the southern GBR and Western Papua New Guinea (Figure 30).

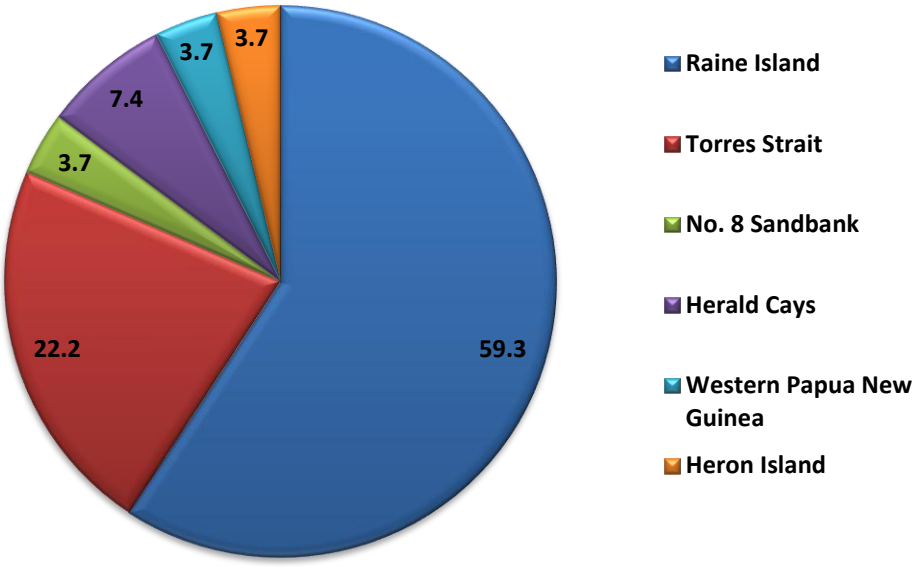


Figure 30: Percentage of tagged adult female green turtles and their respective tagged locations that were recaptured within the Torres Strait during the 2014-15 financial year.

This outcome further supports the hypothesis that the Torres Strait is an important foraging ground for the northern GBR green turtle population and for the nesting female turtles that utilise Raine Island, the largest green turtle rookery in the world.

8. Identified Issues and Gaps

This is the first breeding season that the adapted Queensland DEHP Raine Island methodologies have been implemented at the marine turtle rookeries of the Torres Strait. It is important to note that population trends, issues or concerns cannot be identified after one breeding season of collected data, successive and continuous years of surveys are needed.

The methodologies worked very well recording the high densities of nesting turtles and delivering multiple outcomes that assessed a sample period and respective proportion of the adult female green turtle population present and subsequent hatchlings that can be compared between rookeries.

Despite the success of the methods there are still improvements that need to be made to the Torres Strait marine turtle monitoring project. Some of these have already been identified in the preceding report content:

- Rainfall and/or sand water content is the hypothesised primary variable impacting nesting success based on unrecorded observations. A real-time weather station has been installed at Maizab Kaur, which will record rainfall (mm). The rainfall data collected at Maizab Kaur will assist in supporting any correlation between rainfall and nesting success; however, the climates at Dauar and Maizab Kaur are significantly different. It would be beneficial to also record rainfall at Dauar over the breeding season to compare outcomes between rookeries.
- The hatching success outcomes recorded at Dauar were not a complete and therefore are an inaccurate representation of the actual outcomes as marked nests that could not be found were not recorded. An improved method for marking clutches during nesting surveys and re-locating during hatchling surveys is needed. A dGPS RTK Unit is used at Maizab Kaur, however, there is no certainty that the equipment and expertise would be available to undertake surveys of both rookeries.
- It is currently assumed that the dGPS RTK Unit marked clutches at Maizab Kaur that could not be found during hatchling success clutch excavations were disturbed by nesting green turtles, as there is likely no other explanation. Although not pertinent, it would be beneficial to obtain data that supports this hypothesis.

Significant gaps in this financial year's outputs were the incompletion of the Warul Kawa (Deliverance Island) nesting and hatchling flatback turtle surveys and the central island hawksbill turtle surveys. In both instances the incompletion was unavoidable for different reasons. Every effort should be made to complete the planned surveys in the 2015-16 financial year. In reading the available literature for the central island hawksbill turtle rookeries there is a discrepancy identified between the suggested peak nesting period of hawksbill turtles. Traditional Owners have stated the peak nesting season to be around September annually, while research has reported high nesting numbers in the central islands between December and February annually, with over 500 estimated to have nested at Sassie Island during the 1997 breeding season (Limpus *et al.* 2000). It is recommended that both periods (February and September) be surveyed using the morning after track and nest count method over a week to identify the peak season and to develop a monitoring program based on the outcomes for the nesting hawksbill turtles.

The primary gap of the Torres Strait marine turtle monitoring project is an absence of structured foraging ground surveys to increase our knowledge of the marine turtle demographics that inhabit the waters. As already established the Torres Strait is a significant foraging ground for the northern GBR green turtle population. Aerial surveys have also recorded incredibly large numbers of marine turtles within the Torres Strait region. It is recommended that the process undertaken to review the marine turtle nesting and hatchling baseline survey methods (Section 3) should be repeated with the

focus on developing structured foraging ground survey methods, utilising the same expertise and partnerships to ensure the methodology is robust and will deliver useable outcomes that will assist in Traditional Owners, regional managers and other stakeholders in the sustainable management of marine turtles.

9. Other NRM Activities

9.1 Remote Observation Station and Real Time Weather Station – Maizab Kaur

The TSRA LSMU collaborated with the Australian Institute of Marine Science (AIMS) on a National Environmental Research Program Tropical Ecosystems Hub (NERP TE) funded project titled *Monitoring the health of Torres Strait coral reefs*, which concluded in December 2014. One facet of the project was the installation of remote real-time weather stations at several select locations across the Torres Strait. They were installed in close proximity to Thursday Island, Masig (Yorke Island) and Maizab Kaur. The real-time weather stations record various atmospheric and in-water parameters, including current air and water temperature, wind speed and direction, rain fall, air pressure, light intensity and water visibility (turbidity). The real-time stations were set up to provide:

- *Real-time water temperature and light information as an early warning of potential coral bleaching events;*
- *Development of system models to allow for predictions for future coral bleaching risk based on the current real-time data and future weather patterns;*
- *Real-time weather data to support local boating activities and as an information resource for local communities; and*
- *Detailed above- and in-water observations at key locations to allow for a greater understanding of ocean processes in the Torres Strait* (Bainbridge *et al.* 2015).

The station installed at Maizab Kaur had two purposes, one to record the above- and in-water parameters as well as look at the Fly River influences (Maizab Kaur is the closest Australian land mass to the river), and two to capture still images of the nesting green turtle and sea bird population throughout the year. In addition, the weather parameters collected, in particular rainfall and air temperature, will be used in future surveys to correlate against nesting success, hatching success and temperature at clutch depth to identify influences. As a result two survey stations were installed, one in-water on the northern edge of the fringing reef that holds the in-water sensors (Figure 31a), and one on land adjacent to the lighthouse that holds the weather station, light sensors and remote camera (Figure 31b). The two poles communicate to each other via radio link and data is transmitted back to AIMS via 3G receptions; however, the location of Maizab Kaur is at the limit of the communications range and environmental parameters are only received sporadically, while the photos have to be collected manually from the external hard drive installed.

The initial installation occurred during August, 2014, as a collaborative project with the DEHP, who conducted surveys to identify the current population status of the Bramble Cay Melomy, which is endemic to Maizab Kaur. The installation of the station was not anticipated to be completed during this survey trip due to the trip being pushed forward to accommodate the Melomys survey, which needed to be conducted when nesting turtles were not present. The remote observation station and real-time weather station were completed during the December 2014 nesting green turtle surveys.

The environmental data is currently being transmitted to AIMS; however, the data is not publicly available, which will be rectified this year. The external hard-drive that stores the still photos taken at the rookery was exchanged during the February 2015 hatchling surveys to obtain photos taken over the December 2014 – February 2015 nesting period (Figure 31c). Unfortunately the camera stopped operating after 16 days. In discussions with AIMS representatives this is likely due to the high temperatures sustained over the survey period in addition to the dense arrangement of cables within the housing. A new housing is currently being constructed to deal with these issues and will

hopefully be installed prior to the 2015-16 breeding season. Below are some photos of the towers as well as a photo taken from the remote observing station.

Figure 31: The Maizab Kaur remote observation and real-time weather stations, showing a) the in-water station construction, b) the land station construction, and c) a photo taken with the observation camera on the 7th December 2014 at approximately 22:00, the only light present was natural moon light.

9.2 Seabird Surveys – Maizab Kaur

Maizab Kaur is the largest sea bird rookery in the Torres Strait. Sea birds are culturally important to Torres Strait Islanders, and as requested in the community meeting at Erub (Darnley Island) at the conclusion of the Maizab Kaur nesting turtle surveys, our knowledge and understanding of the sea bird population that inhabit Maizab Kaur needs to improve.

Sea bird surveys were completed during each survey trip to Maizab Kaur during the 2014-15 financial year, including the survey trip to install the remote observing and real time weather station (August, 2014), the nesting survey (December, 2014) and hatchling survey (February, 2015). The

surveys aimed to adhere to the Queensland Parks and Wildlife Services (QPWS) coastal bird datasheet; however, due to the sheer number of sea birds present on the island during certain months the surveys encompassed observational notes on the various species present, population estimates, life-stages observed, behavioural patterns and any specific concerns that may have been witnessed.

Unfortunately, the raw and electronic sea bird survey data collected during the December 2014 nesting turtle surveys were lost when the vessel sank off Warul Kawa (Deliverance Island). The following notes are in the format of the QPWS coastal bird datasheet.

9.2.1 Maizab Kaur Sea Bird Survey Results – 30 August 2014

Table 12: Maizub Kaur Sea Bird Survey Results – 30 August 2014

Site Name:	Maizab Kaur (Bramble Cay)	
GPS Coordinates	**Latitude**	-9.14500
	Longitude	143.87611
Date	**Start**	30th of August, 2014
	Finish	5th of September, 2014
Observers	**TSRA**	Tristan Simpson
	QLD - DEHP	Ian Gynther
Survey Type	Incidental	
Recording confidence	Estimate	
% Rookery Seen	100% of interior and exterior - small island cay	
Survey Overview	Surveys were attempted during the field trip to Maizab Kaur as a secondary activity to increase our knowledge of the coastal bird population utilising the small island cay. It was decided that undertaking the survey would not garner accurate results due to the incredibly large population of sea birds present on the island. The figures are only an estimate as it was impossible to determine accurate numbers of total population let alone to identify numbers associated with the categories of the QPWS coastal bird datasheet. It was evident that the island had been subjected to storm surge that breached the islands interior, identified by a pathway with patches of dead vegetation, an apparent channel and various debris piled at its end (primarily bird eggs and logs). No differentiation between times and tides was made due to the high numbers present for the entirety of the day. Photos and videos were recorded to complement the data and notes collected.	
Breeding Species		
Species	**Population Estimate**	**Rookery Notes**
Sooty Tern - *Onychoprion fuscata*	+10,000	• **Nests:** Uncounted, but present and numerous. Adults were observed laying eggs and roosting during the survey. Sooty terns nested alongside Common Noddys and were denser near and around vegetated areas. During the survey trip participants disturbed ground to install a remote monitoring tower. On returning to the site the following day (approximately 12-15hours later) about a dozen sooty terns had layed eggs in the disturbed sand, these were unharmed for the

		remainder of the survey trip. • **Chicks:** No chicks were observed during the survey. • **Young and Adolescents:** Uncounted, but estimated that well over a thousand of the birds were fledglings at various stages. They displayed feather types indicative of adolescents with various capacities to fly, some were able while others were completely flightless. They were observed forming large groups of mixed fledgling species within the interior of the island (100-300), mainly with common noddy fledglings. • **Adults:** Adult birds were primarily observed in the centre of the island; distribution extended across vegetated areas as well as sandy habitats, but away from the waters edge. Adults were observed feeding their young.
Common Noddy - *Anous stolidus*	+5,000	• **Nests:** Uncounted, but present and numerous. Adults were observed laying eggs and roosting during the survey. Common Noddys nested alongside Sooty terns and were denser near and around vegetated areas. • **Chicks:** Several chicks were observed during the survey. They were by no means abundant, but they were present in low numbers. • **Young and Adolescents:** Uncounted but numerous. As with the Sooty Terns, abundant Common Noddy young and adolescents of various development stages were observed within the centre of the island. They were observed forming large groups of mixed fledgling species, primarily with Sooty Terns. • **Adults:** Adults were observed in both the centre of the island as well as around the shoreline. Those observed in the centre of the island were associated with nests or young/adolescents. The adults observed around the shoreline periphery gathered in dense groups of several hundred individuals, some with mixed species present such as Brown Boobys, Crested Terns and some Sooty Terns.
Brown Booby - *Sula leucogaster*	500-800	• **Nests:** No Brown Boobys were observed nesting. • **Chicks:** No chicks were observed during the survey period. • **Young and Adolescents:** Uncounted but abundant. They were distributed across the extent of the island with no apparent groupings or location preferences. Variable development stages were observed; from individuals still with large patches of down to those close to adulthood that were observed spreading their wings in an attempt to learn to fly. • **Adults:** The majority of Brown Boobys observed were adults (full physical development with adult plumage). It is uncertain as to whether they were new to adulthood or not. Some adults were observed feeding their young within the centre of the island. The majority of adults were located around the shoreline periphery, in particular perched on top of rocks/cliffs.

Non-Breeding Species		
Lesser Frigate - *Fregata ariel*	4-6	• Small flocks of 3-7 great and lesser frigates (mixed group) gliding around the circumference of the island. • They were not observed landing on the island.
Great Frigate - *Fregata minor*	6-8	• Small flocks of 3-7 great and lesser frigates (mixed group) gliding around the circumference of the island. • They were not observed landing on the island.
Ruddy Turnstone - *Arenaria interpres*	9-12	• Small groups (3-6) were observed foraging in the shallows around the circumference of the island.
Crested Tern - *Thalasseus bergii*	24-36	• Small flocks of crested terns (approximately a dozen) were observed gathering near the shoreline around the circumference. • No courtship, roosting or foraging was observed.
Bridled Tern – *Onychoprion anaethetus*	10-14	• Several bridled terns were observed amongst the sooty terns and common noddys in the centre of the island around the vegetation. • Several pairs were observed displaying courtship behaviour, but were also commonly seen individually. • No bridled terns were observed roosting.
Silver Gull - *Chroicocephalus novaehollandiae*	2-3	• Two were observed near the shoreline at one time, there is potential for a third individual. • They were not observed foraging or roosting.
Wandering Tattler - *Tringa incana*	2	• Two individuals were observed foraging near the shoreline. • One was observed with a leg missing and was noted as the individual previously observed during the March 2014 survey.

9.2.2 Maizab Kaur Sea Bird Survey Results – 11 February 2015

Table 13: Maizub Kaur Sea Bird Survey Results – 11 February 2015

Site Name:	Maizab Kaur (Bramble Cay)	
GPS Coordinates	**Latitude**	-9.14500
	Longitude	143.87611
Date	**Start**	11th of February, 2015
	Finish	11th of February, 2015
Observers	**TSRA**	Tristan Simpson
Survey Type	Planned – Observational	
Recording confidence	Estimate	
% Rookery Seen	100% of interior and exterior - small island cay	
Survey Overview	The survey was conducted on the 11th of February during the hatchling surveys as a primary objective to increase our knowledge of the coastal bird population utilising the small island cay at varying times throughout the year. There were less birds and species present on the island in comparison to the August 2014 survey, allowing a more accurate count and final estimate of the species present and their associated behaviours.	
Breeding Species		
Species	**Population**	**Rookery Notes**

	Estimate	
Brown Booby - *Sula leucogaster*	720-750	• **Nests:** An estimated 50-60 adult Brown Boobys were observed on nests with eggs present. • **Chicks:** Approximately 90-100 chicks were recorded. All observed chicks were large, almost the size of the adults, all still had predominant white down present except around the margins of the wings. • **Young and Adolescents:** 8-10 young to adolescent Brown Boobys were recorded and observed attempting to fly. • **Adults:** Approximately 500-550 adult Brown Boobys were observed in the centre of the island around the vegetation. As recorded, a small percentage of adult Brown Boobys were recorded nesting. Approximately 90-100 adult Brown Boobys were observed around the shoreline of the island. • **Other Observations:** The Brown Booby population appears healthy. Adults were observed daily going out to sea presumably foraging. Feeding behaviour of adults to chicks was observed often and the chicks appeared healthy and strong. Only 3 dead chicks were found on the island.
Crested Tern - *Thalasseus bergii*	1,500-1,600	• **Nests:** Approximately 800-900 adult Crested Terns aggregated to the east of the centre pool of water, numerous eggs were observed lying in the sand, however, an actual count of the number of nests was not undertaken as the Crested Terns were observed to be very flighty and disturbance needed to be minimised. • **Chicks:** No chicks were observed during the survey. • **Young and Adolescents:** There were approximately 80-90 fledglings that were observed around the periphery of the central water pool. They were observed staying to the outside of the main Crested Tern nesting area but never ventured far from the main population group. • **Adults:** In addition to the 800-900 observed nesting, approximately 100 were scattered around the periphery of the water hole with no nests present. A second large cluster of approximately 400-450 adults was observed on the sand spit extending from the southern shoreline. A small group of approximately 100-120 were observed on the northern shoreline of the island. • **Other Observations:** Feeding behaviour was observed, numerous Crested Terns were observed flying back into the main nesting group with fish visible from their beaks.
Non-Breeding Species		
Common Noddy - *Anous stolidus*	200-220	• A flock of approximately 200-220 adults was observed on the sand spit that extended from the southern shoreline.

Wandering Tattler - *Tringa incana*	31	• Approximately 31 Wandering Tattlers were observed near the north-western shoreline foraging.

For either of the surveys no significant issues or concerns were observed. Each of the recorded species and respective life stages appeared by all appearances healthy. On each occasion where chicks or young fledglings were present feeding behaviour was observed. Chicks, when present, also appeared healthy and minimal dead chicks were observed. The largest destruction observed occurred during the August 2014 survey, where sea water had clearly breached the berm and spread through a section of the interior destroying a large, uncounted, number of eggs of Sooty Terns. Although the impact on the population is unknown, Sooty Terns were still laying numerous eggs during the survey period, as recorded when the tower was installed and several dozen Sooty Terns laid in the freshly disturbed sand.

Successive surveys need to be completed as a comparison, ensuring that the survey periods are the same as each species seems to differ in presence and abundance during the different months of the year.

9.3 Bramble Cay Melomys Survey – Maizab Kaur

Bramble Cay Melomys surveys were undertaken over six consecutive nights from the 29th August - 5th September 2014. Each night of survey 150 Elliot traps and 10 sensor camera traps were set and checked the following morning; additionally day time searches were undertaken to identify any remains or signs of the melomys.

The island was also mapped by DEHP staff by using a hand held GPS to record the high and low tide lines and the vegetation cover; this activity was undertaken in response to the significant changes observed to the islands shape, size and percentage vegetation cover, which may have impacted the melomys population.

No melomys were snared in the Elliot traps or captured on the images recorded from the remote sensor cameras nor were any remains found.

DEHP staff obtained anecdotal information from commercial fishermen that were present at Maizab Kaur at the time of the survey and have an extended observational history and knowledge of the island and the changes overtime, including melomys sightings; they last observed melomys in 2009. The DEHP will be producing a report on the outcomes and will detail recommendations.

9.4 Water Quality Testing – Maizab Kaur

The TSRA LSMU has been collaborating with the JCU Tropical Water and Aquatic Ecosystem Research Centre (TropWATER) on the deployment of water quality and temperature samplers across the Torres Strait. Maizab Kaur is a location of keen interest for water quality due to its close proximity to the Fly River.

Water quality samplers were deployed at Maizab Kaur for 3-5 days over the three survey trips conducted to Maizab Kaur during the 2014-15 financial year, including 29th August - 5th September 2014; 1st - 9th December 2014; and 9th - 13th February 2015.

The water quality samplers have been sent to JCU TropWATER for analysis, which will be developed into a report that includes the outcomes of other sample locations.

- A garbage clean-up was undertaken, minimal garbage was found during this trip and only amounted to a couple of bags of rubbish.
- A water quality sampler was deployed for the duration of the survey trip.
- A rubbish clean-up was also undertaken with removal of minor amounts of rubbish (4 half-filled bags).

9.4 Rubbish Removal – Dauar and Maizab Kaur

Rubbish removal at both Dauar and Maizab Kaur during the scheduled marine turtle surveys was a secondary objective and was completed on all occasions. The rubbish removed was not recorded. It is noted that rubbish at Maizab Kaur was minimal, typically two full rubbish bags that consisted mainly of plastic water bottles and thongs/flip flops.

The rubbish collected at Dauar was much more considerable and consisted of a wide array of debris. During the December 2014 nesting green turtle survey 15 bags of rubbish and various large items (e.g. screen doors) were removed from Tig and Giar. During the February 2015 hatchling surveys 12 bags of assorted rubbish were removed. Tig, the southern nesting beach, appears to be a camping ground and rubbish has been left by those that use the beach. Rubbish, typically plastic bottles, also accumulates around the southern end of the northern nesting beach Giar around the rocky outcroppings.

In order to quantify the rubbish it is recommended that the survey teams re-instigate the Tangaroa Blue initiative to record and report on the level of rubbish present on the rookeries.

10. References

Bainbridge, S.J., Berkelmans, R., Sweatman, H. and Weeks, S. (2015). Monitoring the health of Torres Strait Reefs – Final Report. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns (pp74).

Ellison, J.C. (1998). Natural History of Bramble Cay, Torres Strait. Atoll Research Bulletin, 455 pp. 1.

Fitzsimmons N.N and Limpus, C.J. (2014). Marine turtle genetic stocks of the Indo-Pacific: Identify boundaries and knowledge gaps. Indian Ocean Turtle Newsletter, Issue 20: 2-18 (pp. 17).

FitzSimmons, N. N., Moritz, C., Limpus, C. J., Miller, J. D., Parmenter, C. J. and Prince, R. (1996). Comparative genetic structure of green, loggerhead and flatback populations in Australia based on variable mtDNA and nDNA regions. National Oceanographic and Atmospheric Administration Technical Memorandum, National Marine Fisheries Service, Southeast Fisheries Science Center 396, 25–32.

Fitzpatrick, R., Thums, M., Bell, I., Meekan, M.G., Stevens, J.D., and Barnett, A. (2012). A Comparison of the Seasonal Movements of Tiger Sharks and Green Turtles Provides Insight into Their Predator-Prey Relationship.

Fuentes, M.M.P.B., Bell, I., Hagihara, R., Hamann, M., Hazel, J., Huth, A., Seminoff, J.A., Sobtzick, S., Marsh, H. (2015). Improving in-water estimates of marine turtle abundance by adjusting aerial survey counts for perception and availability biases. Journal of Experimental Marine Biology and Ecology 471: 77-83.

Hamann, M., Smith, J. and Preston S. (2015a). Flatback turtles of Torres Strait. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns (9pp.).

Hamann, M., Smith, J. Preston S. and Fuentes, M.M.P.B. (2015b). Nesting green turtles of Torres Strait. Report to the National Environmental Research Program. Reef and Rainforest Research Centre Limited, Cairns (15pp.).

Kowarsky, J. (1978). Observations on green turtles (*Chelonia mydas*) in North-eastern Australia during the 1975/76 nesting season. Biological Conservation 13:51-62.

Limpus, C.J. (2008). A biological review of Australian marine turtle species. 2. Green Turtle, *Chelonia mydas* (Linnaeus). The State of Queensland, Environmental Protection Agency.

Limpus, C.J., Carter, D. and Hamann, M. (2001). The green turtle, *Chelonia mydas*, in Queensland, Australia: The Bramble Cay Rookery in the 1979-1980 breeding season. Chelonian Conservation and Biology: International Journal of Turtle and Tortoise Research, 4(1): 34-36.

Limpus, C. J., Miller, J. D., Baker, V., and McLachlan, E. (1983). The hawksbill turtle, *Eretmochelys imbricata* (L.), in North-eastern Australia: the Campbell Island rookery. Australian Wildlife Research 10: 185–197.

Limpus, C.J. Miller, J.D. and Chatto, R. (2000). Distribution and abundance of marine turtle nesting in northern and eastern Australia. Pp. 19-37. In Limpus, C.J. & Miller, J.D. (eds) Final report for Australian Hawksbill Turtle Population Dynamics Project. (Queensland Parks and Wildlife Service: Brisbane).

Limpus, C. J., Miller, J. D., Parmenter, C. J. and Limpus, D. J. (2003). The green turtle, *Chelonia mydas*, population of Raine Island and the northern Great Barrier Reef: 1843–2001. Memoirs Queensland Museum 49(1): 349–440.

Limpus, C. J., Miller, J. D., Parmenter, C. J., Reimer, D., McLachlan, N., and Webb, R. (1992). Migration of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles to and from eastern Australian rookeries. Wildlife Research 19:347-58.

Limpus, C. and Nicholls, N. (2000). ENSO regulation of Indo-Pacific green turtle populations. In: Applications of Seasonal Climate Forecasting in Agricultural and Natural Ecosystems. (Hammer, G., Nicholls, N., and Mitchell, C. Eds.) pp. 399–408. (Kluwer Academic Publishers: Dordrecht.)

Limpus, C., Parmenter, C., Baker, V. and Fleay, A. (1983). The Crab Island sea turtle rookery in the north-eastern Gulf of Carpentaria. Australian Wildlife Research 10:173-184.

Limpus, C., Zeller, D., Kwan, D. and MacFarlane, W. (1989). Sea-turtle Rookeries in North-western Torres Strait. Australian Wildlife Research 16:517-525.

Miller, J. D. and Limpus, C. J. (1991). Torres Strait marine turtle resources. Great Barrier Reef Marine Park Authority Workshop Series 16:213–226.

Norman, J. A., Moritz, C., and Limpus, C. J. (1994). Mitochondrial DNA control region polymorphisms: genetic markers for ecological studies in marine turtles. Molecular Ecology 3: 363–373.

Parmenter, C. J. (1978). Resume of Bramble Cay - results 1977/78 season. Unpublished report to Applied Ecology Pty. Ltd. (Australian National Parks and Wildlife Service, Canberra.)

Parmenter, C. J. (1979). Resume of Bramble Cay - results 1978/79 season. Unpublished report to Applied Ecology Pty. Ltd. (Australian National Parks and Wildlife Service, Canberra.)

Parmenter, C. J. (1980). Incubation of the Eggs of the Green Sea Turtle, *Chelonia mydas*, in Torres Strait, Australia: the Effect of Movement on Hatchability. Australian Wildlife Research 7:487–491.

Pittard, S.D. (2010). Genetic population structure of the flatback turtle (*Natator depressus*): A nuclear and mitochondrial DNA analysis. Honour's Thesis, University of Canberra, Canberra, Australia.

Walker, T.A. (1988). The flora and fauna of Bramble Cay, January 1987. Queensland Naturalist 28:32-36.

Appendix A. Overview of Published Marine Turtle Research and Monitoring Projects in the Torres Strait

Table A1: A Chronological summary of published marine turtle research and monitoring projects* within the Torres Strait –brief project details are given; however, outcomes are omitted purposefully. Relevant outcomes are referenced in the preceding report sections.

*This is not a complete list; it includes only publications made publicly available or copies obtained from colleagues.

Dates	Research Details	Sources
1975-76	**Project:** Observations on the green turtle (*Chelonia mydas*) in north-eastern Australia during the 1975/76 nesting season. • Location: Torres Strait Region, including Maizab Kaur, Dauar Island, Sassie Island and Warul Kawa (Deliverance Island). • Management: Queensland Parks and Wildlife Service. • The project summarises the results of surveys undertaken between October 1975 and July 1976. • The project utilises aerial surveys as well as on-ground surveys to record for all nesting marine turtle species: – Nightly track counts at select rookeries (aerial); – Nesting effort and success (green turtle only); and – Curved carapace measurements (green turtle only).	Kowarsky, J. 1978
1977-80	**Project:** Incubation of the eggs of the Green Sea Turtle, *Chelonia mydas*, in Torres Strait, Australia: The effect of movement on Hatchability. • Location: Maizab Kaur rookery and various Torres Strait Island's Turtle Farms • Management: The project was part of the feasibility of Green Turtle Farming Project (above) and was managed by the Applied Ecology Pty. Ltd. • The project aimed to assess the sensitivity and survivorship of moving green turtle eggs from a rookery (Maizab Kaur) to various marine turtle farms to improve hatchability for farms. • The project found that egg survivorship was the most sensitive to movement between 12-24 hours and 20 days, recommending that if *C.* mydas eggs cannot be transported to their final destination within 3 hours then they should not be moved until at least 20-25 days after deposition.	Parmenter, C.J. 1980
1978-79	**Project:** The Hawksbill Turtle, *Eretmochelys imbricata* (L.), in North-Eastern Australia: the Campbell Island Rookery. • Location: Zapker (Campbell Island) • Management: Queensland National Parks and Wildlife Service. • The project monitored nesting turtle activity on Campbell Island from the 1st of December 1978 to the 16th	Limpus, C.J., e*t al.* 1983

Dates	Research Details	Sources
	of February 1979; the report is the first detailed study of an Australian nesting population of hawksbill turtles. The methodologies used included: – Track and nest counts, including nesting effort and success; – Incubation temperature experiments; – Tagging: capture, mark, recapture, including identification of re-nesting interval; – Measurements, including Curved Carapace Length and weight; – Nest depth, clutch counts and egg size and weights.	
1979-80	**Project:** The Green turtle, *Chelonia mydas*, in Queensland, Australia: the Bramble cay Rookery in the 1979-1980 Breeding Season. • Location: Maizab Kaur. • Management: Queensland Parks and Wildlife Service. • The project aimed to summarise the results of the complete 1979/80 breeding season for the green turtle at Maizab Kaur. • Maizab Kaur was monitored from 9 October 1979 until 29 March 1980 and utilised saturation tagging, amongst other methods, to record: – Breeding season and cycle; – Total nesting female abundance for the rookery; – Nesting effort and success; – Average curved carapace length of nesting females; – Clutch details, including the average clutches laid per female; number of eggs per clutch; incubation period and emergence success; and – Rookery geomorphology from the start and end of the breeding season and associated clutch loss. • The 1979-80 Maizab Kaur breeding season data remains the most comprehensive to date of the breeding biology of the green turtle for the Torres Strait, if not the northern green turtle population.	Limpus, C.J., e*t al.* 2001
1987	**Project:** The Flora and Fauna of Bramble Cay, January 1987 • Location: Maizab Kaur • Management: Queensland National Parks and Wildlife Service. • As per the project title the project gives a brief overview of Maizab Kaur and its flora and fauna during a survey undertaken from the 4-6th of January 1987. • Track counts of nesting green turtles were conducted after the first and second night while on the island, although it is stated that the first nights count is likely to be inaccurate.	Walker, T.A. 1988
1987	**Project:** Sea-turtle Rookeries in the North-western Torres Strait. • Location: Warul Kawa (Deliverance Island), Kerr Islet and Turu Cay. • Management: Queensland National Parks and Wildlife Service.	Limpus, C.J., e*t al.* 1989

Dates	Research Details	Sources
	• The project reports on the outcomes of various survey trips to Warul Kawa (Deliverance Island), Turu Cay and Kerr Islet to tag, measure and conduct counts of nesting turtles and subsequent hatching success: – 19-20 February 1987, Warul Kawa; – 27-28 September 1987, Turu Cay; – 28 September to 15 October 1987, Warul Kawa; and – Unspecified visits to Kerr Islet while survey team camped on Warul Kawa. • In addition, the report analyses the flight reports of coastwatch past Warul Kawa from January 1987 to May 1988, as well as conducting interviews with several Torres Strait Islander communities in the western Torres Strait (Boigu and Badu) to assess the frequency of fishing parties visiting the three surveyed islands.	
1991	**Project:** Torres Strait marine turtle resources. • Location: Torres Strait region • Management: Queensland National Parks and Wildlife Service. • The project gives a brief overview of marine turtle species of the Torres Strait, including: their breeding sites; genetic populations; foraging grounds and migrations; fluctuations in annual breeding numbers; impacts of pollution (rubbish/debris, heavy metals, pesticides, etc.); and notes on considerations for sustainable turtle harvest.	Miller, J.D. and Limpus, C.J. 1991
1992	**Project:** Migration of Green (*Chelonia mydas*) and Loggerhead (*Caretta caretta*) Turtles to and from Eastern Australian Rookeries. • Location: Eastern Australia green and loggerhead marine turtle rookeries and foraging grounds, including the Torres Strait region • The project summarises the outcomes of tagged green and loggerhead turtle recaptures at foraging grounds based on 21 years of tagging at rookeries, identifying migration distances, speeds and routes, and nesting and foraging ground fidelity. • The project also discusses migratory behaviour, imprinting and navigation and reiterates the importance of marine turtle management at a regional/international level based on the genetic stocks migration patterns.	Limpus, C. J., e*t al.* 1992
1995	**Project:** Natural history of Bramble Cay, Torres Strait • Location: Maizab Kaur • Management: National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A. • The project is a naturalist overview of Maizab Kaur that outlines the islands: – Geographical location; – Geology and geomorphology; – Cultural and European history; – Movement of the cay; and	Ellison, J.C. 1998

Dates	Research Details	Sources
	– Flora and Fauna summaries, including the nesting green turtle population that briefly describes previous (and aforementioned) survey outcomes and includes nightly nesting green turtle counts from the 17-19 February 1995 from their survey and reports a major decline in nesting population for the rookery.	
1991-2000	**Project:** Australian Hawksbill Turtle Population Dynamics Project • Location: Australia, including the Torres Strait region • Management: Environmental Protection Agency, Queensland Government. • The project is a comprehensive overview of the Hawksbill Turtle, *Eretmochelys imbricata*, biology, including: – Monitoring methodology; – Distribution and abundance of marine turtle nesting in northern and eastern Australia (all marine turtle species); – Nesting biology of *E. imbricata* in the northern Great Barrier Reef (GBR), primarily Milman Island; – Growth, recruitment, breeding migration and foraging populations. • Of relevance to the Torres Strait, the project undertook intensive, low altitude (60m) aerial surveys over two periods: – 8-11 February 1997: surveyed 145 islands and sand cays of the Torres Strait to coincide with the peak nesting season of the northern GBR (Dec-Feb annually); and – 6-9 July 1999: surveyed islands of the western Torres Strait, south from Warul Kawa (Deliverance Island) to Crab Island to coincide mid-year peak density of Flatback Turtle nesting, *Natador depressus*, and a known dry season *E. imbricata* nesting activity in the western Torres Strait and Cape York Peninsula region. • The report concludes that the northern GBR, Torres Strait and eastern Arnhem Land support one of the most significant Hawksbill populations in the world, with Sassie Island (Long Island), Hawksbury Island and Dayman Island identified as the biggest Hawksbill Turtle rookeries.	Limpus, C.J. e*t al.* 2000
1843-2001	**Project:** The green turtle, *Chelonia mydas*, population of Raine Island and the northern Great Barrier Reef: 1843-2001. • Location: Primarily Raine Island, but includes northern Great Barrier Reef green turtle rookeries, including Maizab Kaur. • Management: Queensland Museum. • The project reports on the European historical use of Raine Island and includes an overview of northern GBR green turtle breeding population for Raine Island and other northern GBR rookeries (including Maizab Kaur). • The document details the methodology used to assess the northern GBR green turtle population at Raine	Limpus, C.J., e*t al.* 2003

Dates	Research Details	Sources
	Island, northern GBR rookery descriptions, historical (European) review of Raine Island, biology of breeding populations within the northern GBR, Raine Island and adjacent rookery (e.g. Moulter Cay) monitoring outcomes, mortality of nesting females, and fluctuations in populations. • The report includes minor references to Maizab Kaur, including a research synopsis for the rookery (brief), and importantly it contains additional nesting effort data collected from Maizab Kaur from the 3-4 January 1987 and 16-17 January 1989.	
Until 2004	**Project:** A biological review of Australian marine turtles. 2. Green turtle *Chelonia mydas* (Linnaeus). • Location: Australia. • Management: Environmental Protection Agency, Queensland Government. • The project provides a comprehensive review of available information on the green turtle populations of Australia up to August 2004, including: – Species taxonomy, global distribution and identification; – Biology of Australian green turtles; – Australian genetic stock differentiation; – The northern GBR breeding stock biology (includes Torres Strait green turtles); – Anthropogenic mortality and diseases; and – The population status. • Similar to Limpus, C.J, *Et al.* 2003, this review provides a concise and comprehensive summary of the northern GBR green turtle population biology for the specified period of the project, that includes outcomes from monitoring and research projects at Maizab Kaur.	Limpus, C.J. 2008
2006-09	**Project:** Proxy indicators of sand temperature help project impacts of global warming on sea turtles in northern Australia. • Location: Five northern Australian rookeries, including Maizab Kaur, Moulter Cay, Milman Island, Ashmore Island and Bare Sand Island. • Management: James Cook University. • The project identifies global warming as a threat to marine turtle populations as sex determination during incubation of eggs is temperature dependant and increasing temperatures will result in a female skewed output from rookeries. The project refines projections of future sand temperatures by including air temperature and high resolution sea surface temperature into the modelling analysis. • The project predicts that by 2070 Maizab Kaur, Moulter Cay and Milman Island will be producing all females, while at Ashmore Island and Bare Sand Island all female production has been predicted as early as 2030.	Fuentes, M.M.P.B., e*t al.* 2009
2002-07	**Project:** A comparison of the seasonal movements of tiger sharks and green turtles provides insights into their predator prey relationship.	Fitzpatrick, R., e*t al.* 2012

Dates	Research Details	Sources
	• Location: Raine Island. • Management: James Cook University. • The project attaches satellite linked transmitters to ten tiger sharks and eight mature, nesting female turtles in order to compare their migration patterns post breeding season. • Although the project isn't focused on the Torres Strait it demonstrates the connection between the Raine Island, the largest green turtle rookery in the world, and the Torres Straits as their primary (six out of eight tracked) foraging ground for the northern GBR green turtle population.	
2012-14	**Project:** Flatback turtles of the Torres Strait. • Location: Warul Kawa (Deliverance Island). • Management: James Cook University. • The project reports on the methodology and results of the annual nesting surveys over the survey period. • Methodology included saturation tagging, collection of genetic and stable isotope samples from nesting flatback turtles as well as foraging green turtles captured on the adjacent reef flat (samples are noted as being stored for later analysis) and the deployment of 11 satellite tags on nesting flatback turtles.	Hamann, M., e*t al.* 2015a
2013	**Project:** Improving in-water estimates of marine turtle abundance by adjusting aerial survey counts for perception and availability biases. • Location: Western and central Torres Straits. • Management: James Cook University. • The project reports on the aerial survey results conducted in November 2013. The surveys were conducted to record dugong abundance across the western and central Torres Strait, excluding the eastern island cluster as there are very low densities of dugongs recorded in that region. The surveys also recorded sightings of marine turtles during the surveys and presents an estimate on total abundance of marine turtles in the Torres Strait that accounts for perception and availability biases and presents options to improve the survey estimates.	Fuentes *et al.* 2015
2006-14	**Project:** Nesting green turtles of the Torres Strait. • Location: Maizab Kaur and Dauar. • Management: James Cook University. • The project reports on the methodology and results of the annual nesting and hatchling surveys over a nine year period, which conducted short period surveys (3-7 survey nights) of saturation tagging in November and December (nesting) and January and February (hatchling) annually.	Hamann, M., e*t al.* 2015b

Appendix B. Torres Strait Marine Turtle Workshop – TSRA Outcomes Report

Location: James Cook University Campus: University Hall – Endeavour Room (see map attached)
Time: 08:30 – 16:30
Chair: Stan Lui

Participants:

- TSRA: Stan Lui, Ron Fujii, Tristan Simpson, Matt Dunn, Frank Loban, Troy Stow, Boggo Gela, Noel Baker and Aaron Bon.
- JCU: Mark Hamann, Shane Preston and Justin Smith.
- QLD Department of Environment and Heritage Protection: Andrew Dunstan, Belinda Norris, Ian Bell, and Col Limpus.
- GBRMPA: Andrew Simmonds.
- AMFA: Steve Hall.

Workshop Goals:

- Increase the TSRA's knowledge and understanding of marine turtle monitoring and research outcomes to date within the Torres Strait and adjacent regions (i.e. Cape York and Raine Island);
- Discuss and finalise the *Torres Strait Dugong and Turtle Management Project: Marine Turtle Nesting and Hatchling Baseline Survey Methods* and associated processes, including:
  - Training of field trip participants;
  - Communication of outcomes: community, regional and national;
  - Collaboration with other stakeholders involved in marine turtle management and/or monitoring/research in adjacent regions outside of the Torres Strait; and
  - Returning tags; and
- Identify monitoring and research gaps and priorities and develop strategies to address them.

Time	Topic	Who
08:00	Arrive: • Meet and greet; • Coffee & tea available on arrival	n/a
08:15	• Start workshop • Welcome to participants • Outline workshop goals and priorities	Stan Lui
08:30	Torres Strait marine turtle monitoring and research outcomes: • Presentation on outcomes to date, including trends, issues and threats; • Include time for participants to ask questions.	JCU
09:30	Raine Island and Cape York marine turtle monitoring and research outcomes: • Presentation on outcomes to date, including relevance to the Torres Strait marine turtle populations. • Include time for participants to ask questions.	DEHP
10:30	Morning tea	n/a
10:45	Torres Strait Dugong and Turtle Project's Marine Turtle Nesting and Hatchling Baseline Survey Methods discussion and finalisation, including: • Overview of proposed activities; • Individual method discussion and review; and • Discussion on the trial of electronic datasheets.	Tristan Simpson

12:30	Lunch	n/a
13:00	Future marine turtle monitoring and research: • Discuss current gaps, issues and questions; • Identify priorities; and • Discuss strategy options for addressing identified priorities.	Stan Lui
14:30	Afternoon tea	n/a
14:45	Process discussion and development: • Training of participants in methodology; • Database development; • Communication of outcomes; • Collaboration with other stakeholders; and • Returning tags **Note:** include a 5min break after an hour.	Stan Lui
16:30	Workshop close	Stan Lui

Outcomes

1. **Increase our knowledge & understanding of monitoring and research outcomes to date within the Torres Strait and Raine Island:**

- Thank you Mark for giving a presentation on the outcomes of the JCU/TSRA collaborative monitoring and research to date on the Torres Strait marine turtle populations, my notes of importance included:
  - The long history of marine turtle monitoring in the Torres Strait from the 1970's;
  - The importance of Dauar as a resilient green turtle rookery against the impacts of climate change that are currently afflicting many low lying rookeries such as Maizab Kaur and Raine Island;
  - The historical detail of Maizab Kaur, it's green turtle population and the rookeries advancing degradation; and
  - The identification of current research and monitoring gaps, in particular the need for improved hatchling emergence data, greater understanding of temperature aspects, and impacts of nest site location in relation to shade and erosion.
- Thank you Andy for giving a presentation on the Raine Island project outcomes and future direction, my notes of particular importance included:
  - The significance of Raine Island as a rookery to the stocks of foraging green turtles within the Torres Strait;
  - The current issues that Raine Island is facing and the subsequent negative repercussions towards the green turtle population's nesting success, hatching success and production;
  - The current research undertaken this nesting season to identify the causes of the reduced hatching success and production; and
  - The management actions and monitoring outcomes to address the recorded changes to the rookery's beach profile.

2. **Finalise the Torres Strait Dugong and Turtle Project's Marine Turtle Nesting and Hatchling Baseline Survey Methods:**

Please find attached for final comment the revised marine turtle nesting and hatchling baseline survey methods that we are going to trial this upcoming nesting season. The most notable changes are that I have removed the Peterson Method and added a General Nesting Turtle Details Method that covers both mass tagging and recording of nesting effort and success across the rookery for low to average nesting effort seasons. I have also made numerous other changes based on the finer discussion points, too many to list individually.

Through discussion it was noted that identifying trends in marine turtle populations requires decades of quality data; with the recommendation that surveys be undertaken during the peak nesting period (mid-December – mid-January) for a timeframe of 14 days to account for the nesting interval and tidal cycle. Robust

sampling methods were debated, with emphasis to focus on saturation tagging of the population (i.e. capturing-tagging-releasing every turtle that enters the rookery during the survey period). It was also identified that in order to establish the 'health' of the rookery (as a short-term outcome) monitoring needs to identify: (1) nesting success; (2) level of clutch loss; and (3) percentage of hatching success. It was noted and understood that compromises need to be made in order to accommodate TSRA resources, capacity, variable nesting season's nesting effort, and localities.

3. Identify monitoring and research gaps and priorities:

- This topic was agreed by participants to need a separate day of discussion.
- The primary identified research and monitoring gap is the current absence of structured foraging surveys:
  - Foraging surveys record valuable marine turtle population data, such as recruitment, survivorship, growth rates, age classes, sex ratios, etc. that you cannot get from monitoring a nesting beach;
  - More discussion would need to be had to develop well-planned and structured foraging survey methods.
- Secondary gaps were to do with obtaining information collected from hunters on the status of the marine turtles harvested (please note this is not in reference to catch data), including:
  - Collecting stomach contents for external analysis to identify factors such as preferred food and seasonal changes;
  - Taking photos of mature female ovaries for external analysis to identify successful nesting scars which can potentially identify maturity/age and new recruits.

4. To develop processes for:

- Training of field trip participants:
  - Using the attached methods a training program will be developed;
  - It will include a mix of PowerPoint presentations, practical demonstrations of the activity as well as completing the datasheets and infield training depending on the methods that will be used during the survey;
  - This season video footage of each method will be recorded and developed into a 'demonstration video to complement the above program;
  - Inexperienced participants will be partnered with experienced participants to assist in learning while completing the assigned tasks.
- Database:
  - This season the data will be recorded and stored into basic Excel Spreadsheets;
  - Once the methods are finalised (after a review this nesting season) a relational database will be developed (e.g. Access Database);
  - All data collected will be submitted to the DEHP for inclusion into their database;
  - All data will also be submitted to JCU as project partners;
  - Data analysis will be undertaken as per the attached Marine Turtle Survey Methods analysis (obviously will be amended as data is collected).
- Communication discussion:
  - Immediate outcome reports will be given directly to the community after the completion of the survey trip;
  - A more detailed nesting season report will be developed for each rookery based on the outcomes of the survey and in the future comparisons to previous years data and analysis;
  - The sea team will be undertaking an annual roadshow around May/June each year to communicate project outcomes to every community and obtain their feedback, including marine turtle monitoring outcomes;
  - Video reports will be trialled during this nesting season to be shown to community during the sea team roadshow;
  - eAtlas will be used as a broad basis for sharing information and data;

- An article will be prepared by TSRA and JCU to be published in the Torres News (potentially other publications too), which will focus on the short term outcomes of the monitoring to date (see method discussion);
- All project reports will be shared once completed/finalised with JCU, DEHP, GBRMPA and the broader adjacent communities (e.g. NPA communities, PNG)

- Tag Returns:
  - It was agreed that the tag return process needs to be reinvigorated to improve tag returns;
  - Please find attached a draft tag return form to assist this process;
  - A series of meetings/workshops with TSRA rangers will be held this week, one topic covered will be to re-establish the importance of returning tag information and to discuss options for improving hunter tag returns;
  - The TSRA will submit tag return information to the DEHP for entry and analysis and will communicate the outcomes to communities, JCU and other stakeholders.