Gnaraloo Turtle Conservation Program

Gnaraloo Bay Rookery
Final Report

Program 2010/11

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1 Copy also provided of '*Gnaraloo Fox Control Program, Report 2010/11, Protection of sea turtle rookeries on the Gnaraloo*

2 Ibid.

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CONTENTS

DOCUMENT REVISION AND ISSUE RECORD 3

ABSTRACT 9

1. BACKGROUND 14

2. INTRODUCTION 16

3. FUNDING AND RESOURCING 18

4. LICENCE 18

5. GNARALOO FOX CONTROL PROGRAM 19

6. GTCP MONITORING PROCEDURE 19

7. THE GTCP TEAM AND WORK DURING 2010/11 20

8. NEW GTCP COMPONENTS 2010/11 22
   - 8.1 Trend analysis of turtle activities 22
   - 8.2 Verification of data through Night surveys 22
   - 8.3 Crab burrow surveys 22
   - 8.4 Community engagement 23
   - 8.5 GTCP on the web 26
   - 8.6 Additional training and reference materials 27
   - 8.7 Further development of monitoring forms, procedure, data bases 27
   - 8.8 Improved mapping 28
   - 8.9 Turtle and fox information flyer and signs 28
   - 8.10 Research on turtle foraging and/or resting sites at Gnaraloo 28
   - 8.11 Recognisance of the additional Gnaraloo rookery 29
   - 8.12 Data sharing with international turtle databases 29

9. TREND ANALYSIS OF NESTING ACTIVITY OVER 8 YEARS 30
   - 9.1 Objectives 30
   - 9.2 Monitored area 30
   - 9.3 Materials and methods 30
   - 9.4 Results 31
   - 9.5 Discussion 35
   - 9.6 Conclusions 36

10 DAY MONITORING 2010/11 37
   - 10.1 Objectives 37
   - 10.2 Monitored area 37
     - 10.2.1 Summary of Study Area 2010/11 37
     - 10.2.2 Permanent Beach Point Markers 37
     - 10.2.3 NEW GBN – BP7 38
     - 10.2.4 BP7 – BP8 38
     - 10.2.5 BP8 – BP9 38
   - 10.3 Materials and methods 38

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10.4 Results 39
10.4.1 Track monitoring 39
10.4.2 Nest disturbances and predation by foxes 45
10.4.3 Nest disturbances by crabs 45
10.4.4 Nest disturbances by environmental conditions 48
10.5 Discussion 50
10.5.1 Study Area 2010/11 50
10.5.2 Number of nests, distribution trend and nesting activity 50
10.5.3 Number of nesting females 52
10.5.4 Nest disturbances by introduced and native species 54
10.5.5 Environmental and location impacts on nests 55
10.5.6 Significance of the Gnaraloo Bay Rookery 55
10.5.7 Potential additional significant rookeries at Gnaraloo 57
10.5.8 Conservation status of Gnaraloo turtles 57
10.5.9 Data integrity 58
10.6 Conclusions 60
10.6.1 Number of nests, distribution trend and nesting activity 60
10.6.2 Number of nesting females 60
10.6.3 Nest disturbance and predation 60
10.6.4 Significance of Gnaraloo Bay Rookery 61
10.6.5 Potential additional significant rookeries at Gnaraloo 61
10.6.6 Conservation status of Gnaraloo turtles 61

11 NIGHT SURVEYS 2010/11 63
11.1 Objectives 63
11.2 Survey area 63
11.3 Materials and Methods 63
11.4 Results 64
11.4.1 Species identification 64
11.4.2 Nest activity type determination 65
11.5 Discussion 66
11.5.1 Species identification 66
11.5.2 Nest activity determination 66
11.6 Conclusions 68
11.6.1 Species identification 68
11.6.2 Nest activity determination 68

12 CRAB BURROW SURVEYS 2010/11 69
12.1 Objectives 69
12.2 Survey area 69
12.3 Materials and methods 69
12.4 Results 69
12.4.1 Density and Vertical distribution of crab burrows 70
12.4.2 Horizontal zonation of crab burrows 70
12.5 Discussion 71
12.5.1 Density and Vertical distribution of crab burrows 71
12.5.2 Horizontal zonation of crab burrows 71
12.6 Conclusions 72

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12.6.1 Density and Vertical distribution of crab burrows 72
12.6.2 Horizontal zonation of crab burrows 72
13 RECOMMENDATIONS 73
13.1 Day monitoring 73
13.1.1 Pre-season training 2011/12 73
13.1.2 Study Area 2011/12 73
13.1.3 Day monitoring program 2011/12 74
13.1.4 Nest markers 2011/12 74
13.2 Night surveys 2011/12 75
13.3 Crab burrow survey 2011/12 76
13.4 Overall 76
13.4.1 Essential pre-season servicing of Gnaraloo Weather Station ... 76
13.4.2 Essential program equipment 2011/12 76
13.4.3 Removal of fencing remnants 77
13.4.4 Aerial surveys in future 78
13.4.5 Monitoring of Gnaraloo Northern Rookery 78
13.4.6 Community volunteer and school involvement during 2011/12 78
13.4.7 GIS software and spatial analysis during 2011/12 80
13.4.8 Development of GTCP specific Access database in future 81
13.4.9 Future statistical analysis and design 81
13.4.10 Continuation of Gnaraloo Fox Control Program 82
13.4.11 Recruitment of GTCP team 2011/12 82
13.4.12 Pre-season arrival 2011/12 83
13.4.13 Vehicle access to the Gnaraloo Bay Rookery 84
13.4.14 Tasks at start of season 2011/12 85
13.4.15 Recommended future research 86
14. GLOSSARY 89
15. REFERENCES 94

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FIGURES AND CHARTS

Trend analysis of 8 years of Gnaraloo data

Figure 1a: **Temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 – 2011) (3D representation)**

Figure 1b: **Temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 – 2011) (Line graph representation)**

Figure 2: **Polynomial trendline of temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 - 2011)**

Day monitoring 2010/11

Figure 3: **Total number of Nests, UNAs and U Tracks per species within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 4: **Percentage composition of all turtle beach activities within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 5: **Species composition of recorded turtle nests within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 6: **Daily Loggerhead (*Caretta caretta*) nest count within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 7: **Progressive and cumulative number of Loggerhead (*Caretta caretta*) nests per week within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 8: **Total Loggerhead (*Caretta caretta*) beach activity per week within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 9: **Total number of Loggerhead (*Caretta caretta*) Nests, UNAs and U Tracks per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 10: **Percentage of turtle nests disturbed, predated and not impacted by crabs within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 11: **Percentage of Loggerhead (*Caretta caretta*) nests disturbed, predated and not impacted by crabs per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 12: **Cumulative percentage of Loggerhead (*Caretta caretta*) nests disturbed, predated and not impacted by crabs per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 13: **Conservative percentage of turtle nests impacted by environmental conditions (winds and tides) within Study Area 2010/11 (13/11/10 – 07/02/11)**

Figure 14: **Percentage of endangered sea turtle species within Study Area 2010/11 (13/11/10 – 07/02/11)**

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Night surveys 2010/11

Figure 15: Percentage of species identification correlation within Night monitored sub-section 2010/11 (19/11/10 - 18/01/11)

Figure 16: Percentage of nest identification correlation within Night monitored sub-section 2010/11 (19/11/10 - 18/01/11)

TABLES

Abstract

Table 1: Comparison of percentage and number of turtles during 2008/09, 2009/10 and 2010/11

Day monitoring 2010/11

Table 2: Percentage of species composition during 2008/09, 2009/10 and 2010/11

Table 3: Number of nests per species during 2008/09, 2009/10 and 2010/11

Table 4: Number of nesting females per species during 2008/09, 2009/10 and 2010/11

ATTACHMENTS

PHOTOS PLATES 2010/11

MAPS 2010/11

GTCP SCHOOL FLYER 2010/11

GNARALOO WEATHER STATION DATA 2010/11

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ABSTRACT

This report contains information on sea turtle nesting activities at the Gnaraloo Bay rookery during 2010/11.

The *Gnaraloo Turtle Conservation Program* (**GTCP**) was modified during 2010/11 following the recommendations of the 2 previous years of monitoring (2008 – 2010). In addition, a trend analysis of 8 years of data (i.e. 5 years of informal monitoring prior to the GTCP and 3 years of formal monitoring by the GTCP), a night survey component and a crab burrow study (density and distribution) were added to the program during 2010/11.

Further research over several seasons is required to establish conclusive baselines for the data obtained during 2010/11. It is recommended that data in future years be cross-correlated with abiotic data sourced from the onsite weather station.

Gnaraloo has arranged for the raw handwritten GTCP Data sheets (2008 – 2011) and the informal handwritten data records (2000 – 2008) to be ordered, bound and available in report form.

Trend analysis of Loggerhead nesting activity over 8 years

Data collected by a community member over a 5 year period from 2000 – 2008, **prior to and independently of the GTCP**, was electronically processed and reviewed. Given inconsistency in the data sets from 2000 - 2008, further analysis occurred only of data on the temporal distribution of annual Loggerhead (*Caretta caretta*) nesting activity (i.e. the beginning, peak and end of the annual Loggerhead nesting season).

The informal data sets (i.e. 2000 – 2008) were then analysed with the GTCP formal data sets (i.e. 2008 - 11) in order to produce a trend analysis of Loggerhead nesting activities within the Gnaraloo Bay Rookery over 8 years. Opinion, technical and statistical assistance and advice were sought from experts in the field.

A clear temporal distribution pattern has been highlighted and 3 fundamental moments of the annual Loggerhead nesting season at the Gnaraloo Bay Rookery have been defined as follows:

- **Start of the nesting season:** around 17 November.
- **Peak of the nesting season:** around 10 January.
- **End of the nesting season:** around 22 February.

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From 13 November 2010 to 7 February 2011, a total of 426 turtle nests, inclusive of all species, were recorded within the Gnaraloo Bay Rookery. The first nest was dug on 15 November 2010 and the last on 4 February 2011.

The dominant nesting species observed in the rookery was endangered Loggerhead (*Caretta caretta*) turtles (94%). The Study Area 2009/10 consisted of the area between the Gnaraloo Bay North marker and the Beach Point 9 marker (**GBN – BP9**) (i.e. the Gnaraloo Bay Rookery). The Study Area 2010/11 remained the same, but the various sub-sections were re-arranged.

The nesting season 2010/11 peaked earlier (with 64 Loggerhead nests dug during 3 - 9 January 2011) and ended earlier (on 5 February 2011) (monitoring efforts ceased on 7 February 2011) than previous years. Less total turtle nests was recorded than during 2009/10. This might be due to significant impacts from consecutive cyclones during the nesting season 2010/11.

Approximately 1 out of 2 turtle beach activities within the Gnaraloo Bay Rookery during the nesting season 201011 resulted in a nest.

Turtle activities were predominantly recorded in the northernmost sub-section BP8 - BP9, with more than 60% of total season activity. BP8 - BP9 was also the preferred nesting sub-section for Loggerhead turtles. BP7 - BP8 was the lowest sub-section in terms of beach activities recorded.

The percentage of species composition, number of nests per species and number of nesting females per species varied considerably between the monitoring seasons 2008/09, 2009/10 and 2010/11 (refer Table 1 below). Based on the difficulty of accurately identifying a Hawksbill track compared to a Loggerhead track and the margin of error in species identification recorded by the GTCP teams 2009/10, it is likely that data recorded is more accurately reflected during 2008/09 and 2010/11 than 2009/10.

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		2008/09	2009/10	2010/11
Loggerhead *Caretta caretta*	Percentage species composition	90%	77%	94%
	Number of nests	329	402	402
	Number of females	82 (range 66 - 110)	100 (range 80 - 134)	100 (range 80 - 134)
Green *Chelonia mydas*	Percentage species composition	2%	6%	2%
	Number of nests	9	30	8
	Number of females	2	5	1
Hawksbill *Eretmochelys imbricata*	Percentage species composition	5%	15%	0.5%
	Number of nests	20	78	2
	Number of females	8	31	1

Note: Seasonal totals for 'Percentage species composition' are rounded and not 100% as some nests each season are unable to be identified due to track erosion by the wind and tide fluctuations. Number of females are rounded.

Table 1: Comparison of percentage and number of turtles during 2008/09, 2009/10 and 2010/11

The monitoring season 2010/11 consisted of 87 sample days. No fox tracks were recorded within the Study Area during this time. In order to maintain fox numbers to a minimum, it is strongly recommended that structured fox baiting events continue to be undertaken in future as soon as fox tracks are observed by GTCP researchers within the Gnaraloo Bay Rookery and to repeat the baiting events at the beginning of each month during the turtle breeding season (November – April) and prior to the annual fox breeding season (May).

Crab disturbance (35%) and predation (38%) on turtle nests were significant during the nesting season 2010/11 (cumulatively 73%), impacting the areas of high nesting activities. Both Golden ghost crab (*Ocypode convexa*) and Running ghost crab (*Ocypode ceratophthalma*) were witnessed to prey on turtle hatchlings. There are at least 4 species of crabs present within the Gnaraloo Bay Rookery and the impact by all species of crabs on turtle nests and hatchlings needs to be further investigated in order to draw any definite conclusions.

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Cyclone Bianca during January 2011 significantly impacted beach profile and eroded a large number of turtle nests within the Gnaraloo Bay Rookery. Those beaches within the rookery that are not protected by adjacent fringing reefs experienced the highest degree of erosion and this often coincided with the highest nesting densities (BP 8 – BP9).

A rookery north of the current study area has been identified during repeat aerial survey. Because of the close proximity of the Gnaraloo Bay Rookery and the Gnaraloo Northern Rookery, it is possible that nesting females use both rookeries during the same nesting season which would mean a potential current underestimation of the nesting female population size at Gnaraloo. However, further research needs to be conducted before any definite conclusions can be made.

Night monitoring 2010/11

Night surveys at Gnaraloo occurred for part periods from 19 November 2010 – 18 January 2011. Night surveys were undertaken in order to check the correlation between day results and observations at night in order to confirm correct species identification and nest activity characterization. Night research efforts were confined to the area between Beach Point 8 marker and Beach Point 9 marker (**BP8 - BP9**) given its high density of activities within a relatively small area.

In terms of species identification, 96.5% of results positively correlated between the night surveys and morning track monitoring. The 2 species misidentifications occurred during the first month of monitoring. After 1 month of frequent night surveys and daily morning monitoring, the GTCP team members' knowledge and species identification reached 100% accuracy and correlation. The results confirm the accuracy and the integrity of 2010/11 data for species identification and show that several weeks of training in track monitoring are essential in order to become 100% efficient and reliable in terms of species identification.

In terms of nest activity determination, 89% of results positively correlated between the night surveys and the morning track monitoring and 11% negatively correlated. This margin of error can be explained by the lack of experience of the GTCP team members in nest identification (especially at the start of the nesting season), but also by a wide variety of environmental conditions impacting the tracks as well as nest data collection. Becoming 100% efficient in terms of Loggerhead nest activity determination may be hard to achieve even after many years of experience in Loggerhead nest identification. Future GTCP researchers need to consider as many clues as possible and provide the most appropriate judgment in order to reduce the margin of error in nest activity type determination. The results confirm a good accuracy in nest activity type determination, but also

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highlight a non-negligible source of error that has probably led to an under-estimation of the number of nests (i.e. identified as UNAs through the nesting season but not checked by night surveys) within the Gnaraloo Bay Rookery during 2010/11. It can be assumed that this kind of underestimation may also have occurred during previous monitoring seasons 2008/09 and 2009/10.

Crab burrow surveys 2010/11

Crab burrow surveys were conducted in the Gnaraloo Bay Rookery for part periods from 12 December 2010 – 7 February 2011.

Crab burrows were present all along the rookery, from GBN – BP9. The majority of burrows was distributed in the northern part of the rookery (i.e. from halfway between BP7 – BP8 northwards to BP9), with dynamic beaches, soft sands and mobile dune systems. This distribution correlated with areas of high turtle nest density, reinforcing the hypothesis of a relationship between the crab and turtle populations.

Observation of horizontal zonation showed the highest density of crab burrows in the Inter-tidal zone (71%), as opposed to the Supra-tidal and Dune zones. However, the presence of the majority of crab burrows in the Inter-tidal zone is not an impediment to easy access for crabs to turtle nests on the beach.

Further studies need to be developed in order to provide additional information on the dynamics, behaviour, ecology and size of crab populations in the Gnaraloo Bay Rookery.

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1. BACKGROUND

Gnaraloo Station is situated on the Ningaloo Coast, approximately 150km north of Carnarvon adjacent to the *Ningaloo Marine Park* (**NMP**), in a National Heritage listed area in Australia (refer Maps). The Ningaloo coast has significant sea turtle rookeries, with Loggerhead (*Caretta caretta*), Green (*Chelonia mydas*), and Hawksbill (*Eretmochelys imbricata*) turtles consistently nesting in large numbers along the coast. The IUCN Red List 2011 classifies the Loggerhead and Green turtles as endangered species, with the Hawksbill turtle being listed as critically endangered species.

Since 2005, Gnaraloo has initiated and managed the GTCP to monitor and protect sea turtle rookeries on its coastline, through the engagement of volunteers and involvement of DEC Exmouth District, Western Australia. The GTCP Day monitoring component is based on the *Ningaloo Turtle Program* (**NTP**) in Exmouth, a partnership between DEC and the Cape Conservation Group (**CCG**). The GTCP contributes to the establishment of baseline for an area with little existing scientifically verified turtle information, protection of endangered marine species and critical coastal habitat, biodiversity conservation, informed management activity, community engagement through volunteers and increased public awareness of conservation issues.

The Gnaraloo program concerns Loggerheads as distinguished from the conservation work at Exmouth where Green turtles re more prevalent.

The GTCP has developed further during the monitoring season 2010/11. Gnaraloo executes the rookery monitoring program while DEC provides pre-season training of GTCP researchers and support to the program through the season. Program activities under the GTCP include attracting and managing the required scientists and community volunteers, daily baseline data collection and entry into required databases, data analyses and production of season-end report with results and findings. Each season since 2008, Gnaraloo and DEC, Exmouth District have undertaken onsite information exchange visits at Gnaraloo.

The GTCP also hosted visits by representatives from Government departments as well as research teams from the University of Western Australia (Western Australia) and James Cook University (Queensland).

The GTCP is supported by a separate but complimentary predation control program managed by Gnaraloo and a specialist pest contractor, with support from DEC. The *Gnaraloo Fox Control Program* commenced during 2008, with contributory funding from the Australian Government (*Caring for our Country, Community Coastcare*). Gnaraloo initiated and developed this predation

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minimisation program as an essential accompaniment to the GTCP. The sole objective of the fox control program is to protect turtle rookeries at Gnaraloo and reduce critical threats to egg chambers and hatchlings during the annual breeding season. It is not linked or directed at enhancing economic or pastoral production. Gnaraloo identifies and addresses linkages between the annual turtle and fox control programs, including essential liaison with the expert third party contractors and State agencies, to provide recommendations for informed and adaptive management for most effective and efficient on-ground protection of the Gnaraloo rookeries.

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2. INTRODUCTION

According to the Great Barrier Reef Marine Park Authority (Australian Government), 6 sea turtle species are known to breed in Australian waters. Of these, 3 are known to nest at Gnaraloo, including endangered Loggerhead (*Caretta caretta*) turtles with lesser numbers of endangered Green (*Chelonia mydas*) and critically endangered Hawksbill (*Eretmochelys imbricata*). Both Green and Hawksbill turtles have become more endangered since formal turtle research commenced at Gnaraloo during 2008 at which time both these species were listed as vulnerable. The status of Loggerhead turtles has remained as endangered.

As turtle populations have been on the decline worldwide, studying these species' nesting sites within Australia is of utmost importance. Studies reveal that only a small percentage of turtle hatchlings survive to sexual maturity, which may take 30 years or more for Loggerheads. Protection of endangered sea turtles at Gnaraloo is a local issue for the Ningaloo coast, but also one of the national and international biodiversity significance. The GTCP is in its third year of operation under the initiative of the Gnaraloo leaseholder and guidance, development and management of Gnaraloo's Environmental Advisor.

Gnaraloo has approximately 65km of coastline and GTCP researchers currently monitor an approximately 7km area, within the Gnaraloo Bay Rookery. The GTCP 2010/11 consisted of 3 months of daily monitoring, from 13 November 2010 - 7 February 2011. The research included a Day monitoring program, Night and crab surveys.

Long term goals of the GTCP include determination of the significance of Gnaraloo rookeries to turtle populations locally, nationally and globally as well as development of informed and effective management actions for the conservation and protection of Gnaraloo turtle populations. It also aims to create community awareness and support for the conservation of all sea turtles and their environments. Specifically, the objectives of the GTCP are as follows:

Overall

- Identify significant rookeries, relative significance, trends and management issues for sea turtles along the Gnaraloo coastline to assist conservation of endangered species and biodiversity protection.
- Establish baseline for sea turtle populations along the Gnaraloo coastline, an area for which there is little existing scientifically verified data or information on turtles.

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- Provide accurate and reliable data on the Gnaraloo sea turtles for informed management activity.
- Implement effective protection measures along significant rookeries along the Gnaraloo coastline, for protection of important turtle breeding areas.
- Develop scientific volunteers through seasonal involvement and participation with the program.
- Engage the community through volunteer activity and increase public and visitor awareness of sea turtles and coastal conservation issues.

Trend analysis 2010/11

- Identify trends in turtle nesting activities in the Gnaraloo Bay Rookery.

Day monitoring 2010/11

- Identify the number of nests, distribution trends and number of breeding females in the Gnaraloo Bay Rookery.
- Identify disturbance and predation rates of turtle nests (eggs and hatchlings) by native and introduced predators during the monitoring period.
- Determine the significance of the Gnaraloo Bay Rookery.
- Determine the level of environmental impacts on turtle nests.
- Through aerial survey, identify and confirm any additional potential significant rookeries along the Gnaraloo coastline.
- Monitor the conservation status of sea turtle species in the Gnaraloo Bay Rookery.

Night surveys 2010/11

- Determine the margin of error in species identification and determination of nest activity type through morning track monitoring.
- Confirm the presence of Hawksbill (*Eretmochelys imbricata*) turtles in the Gnaraloo Bay Rookery by visual identification using morphological evidences.

Crab surveys 2010/11

- Investigate and study the evolutionary relationship between the turtle and crab populations in the Gnaraloo Bay Rookery.

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3. FUNDING AND RESOURCING

During the inaugural formal monitoring season 2008/09, the Gnaraloo leaseholder and the Australian Government (with contributory funding under the then *Envirofund Round 10*) funded the GTCP.

During the season 2009/10, the Gnaraloo leaseholder provided all required financial support and in-kind contributions to enable the operation of the GTCP.

During the season 2010/11, the Gnaraloo leaseholder met the required financial and in-kind contributions to the GTCP, including for program planning, on-ground research, technical data analysis, reporting, and project management. The Australian Government contributed through its *Caring for our Country*, *Business Plan 2010/11*, to the introduction of a new program element: namely, increased community involvement with the GTCP. Esri Australia, through its *Conservation Grant Program*, generously provided a full licence of ArcGIS software at no cost during the season for improved spatial analysis and production of higher quality maps.

4. LICENCE

The GTCP 2010/11 was under taken with approval from the Department of Environment and Conservation (**DEC**), under Regulation 17 Licence issued under the Wildlife Conservation Act 1950 and the Wildlife Conservation Regulations 1970.

At the end of the monitoring season, the GTCP enters the season's results into the web-based 'DEC Fauna Survey Database' (https://secure.dec.wa.gov.au/apex/pls/fauna/f?p=101:1:1735533654806623::NO). The DEC Fauna Survey Database contains records of Western Australian fauna from sources including historical reports, DEC staff, survey data from major projects, consultants (as part of the scientific licence procedure) and the general public. It is an online system of data entry, maintenance and distribution that is accessible to licence holders and is managed by DEC.

The information is available for viewing and use by scientists, researchers and the public, who may access data relating to the distribution of fauna by using the DEC NatureMap website. The DEC NatureMap contains data from the DEC Fauna Survey Database and a range of other datasets, including the WA Museum FaunaBase database.

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5. GNARALOO FOX CONTROL PROGRAM

The *Gnaraloo Fox Control Program* (**GFCP**) is a separate but complementary program to the GTCP that was developed as a partnership between Gnaraloo and DEC Exmouth District during 2008. The GFCP fieldwork component was developed by a licensed specialist third party pest controller, Animal Pest Management Services (**APMS**), who undertakes seasonal on-ground works.

Foxes are listed nationally as a key threatening process, posing a significant threat to Australia's native animals. The GFCP was developed due to a high level of European Red Fox (*Vulpes vulpes*) predation of turtle egg clutches and hatchlings. Under the GFCP, fox baiting is undertaken during the annual turtle breeding season (November – April) (to protect turtle eggs and hatchlings) as well as prior to the fox peak breeding season (May).

The GFCP uses specialized purpose made 1080 (sodium fluoroacetate) baits at turtle beaches, surrounding hinterlands and adjacent buffer zones from the southern to northern boundary of Gnaraloo. The objectives of the program are to minimise towards zero fox disturbance and predation of turtle rookeries (egg chambers and hatchlings) on beaches along the Gnaraloo coast.

For an overview of the GFCP, refer to reports by APMS (June 2011, February 2010, November 2009, January 2009 and December 2008).

6. GTCP MONITORING PROCEDURE

The methodologies and protocols used during the research season 2010/11 are contained and described within the *GTCP Monitoring Procedure 2010/11* (Hattingh *et al*., 2011).

GTCP day monitoring activities are based on the beach monitoring practices of the NTP, including the *Turtle Monitoring Field Guide* (CCG 2007) and *Guide to Turtle Track Beach Monitoring in Australia* (DEC, Lewis *et al*. 2008). GTCP night monitoring and crab survey procedures were developed by GTCP researchers, under the guidance of Gnaraloo's Environmental Advisor, and are based on research carried out in Australia and overseas.

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7. THE GTCP TEAM AND WORK DURING 2010/11

The GTCP is undertaken under the ongoing guidance, direction and project management of Gnaraloo's Environmental Advisor (**GEA**), an experienced environmental scientist who ensures overall planning, development, co-ordination and adaptive management of the GTCP and GFCP for responsible protection of onsite rookeries. GEA manages the monitoring activities by seasonal volunteers as well as scope of works, data collection, analysis, reporting and project management from year to year. GEA has assisted Gnaraloo with advice and management of operational activities since 2005 when the current leaseholder, Mr. Paul Richardson, commenced onsite.

Following the successful development and use of the *GTCP Researcher Recruitment Program* during 2008/09 and 2009/10, Gnaraloo employed the program during 2010/11 to recruit the required number (3) of scientists for the research season. This effort focused on attracting and appointing capable candidates from local, national, and international fields. The GTCP recruitment process was again competitive during 2010/11, with more than 30 qualified and skilled applicants from Australia and overseas. After short-listing preferred candidates and conducting interviews, the GTCP team was appointed, comprising of:

- Mr. Matt Boureau (*Team Leader*);
- Ms. Marie Duffy (*Volunteer Co-ordinator*); and
- Mr. Mark Wall (*GIS Cartographer*).

Mr. Boureau has a MSc. Marine Biology (University of New Caledonia, New Caledonia) and has previous experience on sea turtles (Costa Rica), tropical fish and coral reefs (New Caledonia) and peregrine falcons (Tanzania). Ms. Duffy has a BSc. Honours Zoology (National University of Ireland), with previous experiences in sea turtles (Costa Rica), whales (Australia) as well as teaching (Ireland). Mr. Wall is currently in his final year of BSc. Marine Science and Environmental Management (Murdoch University, Western Australia) and has previously mapped coastal sand movements, vegetation types and cover (Western Australia).

The GTCP team 2010/11 received pre-season training and assessment in Western Australian turtle monitoring procedures and protocols by the Department of Environment and Conservation (**DEC**) and the Cape Conservation Group (**CCG**), under the Ningaloo Turtle Program (**NTP**) in Exmouth. This included turtle track identification and monitoring protocols as well as correct data entry into the monitoring form. Ms. Duffy received this training over 3 days during November 2010 and Mr.

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Boureau and Mr. Wall received 3 days of training during December 2010. All GTCP tem members successfully completed the training and assessment program.

Under guidance by GEA, the GTCP team 2010/11 undertook and completed the seasonal program, including track monitoring, data collection, analysis and reporting. The program required 3 months of daily monitoring along the coastline, from 13 November 2010 to 7 February 2011. Data sets from monitoring activities were daily entered into databases.

The GTCP team 2010/11 had daily scientific, program, operational and station duties and responsibilities. The team reviewed numerous reference documents related to turtle research and conservation programs to design the additional research components of the program during 2010/11. The team also presented onsite and offsite overviews of the program and preliminary findings to various groups, including to DEC, volunteer groups, visitors and to a school in a regional town. Under guidance by GEA, the GTCP team drafted this technical report with data, results, discussion and recommendations for future.

GEA undertook 2 site inspections of the GTCP during 2010/11: at the end of November 2010 and during February 2011, for review and guiding on-ground activities as well as host the information exchange visit by DEC). During such time, GEA and the GTCP team 2010/11 provided a PowerPoint presentation on the program to a senior officer of DEC, Mr. Matthew Prophet, and a turtle tracker trainer from the NTP, Mr. Colin Valentine. The presentation detailed monitoring procedure and protocols as well as preliminary findings and recommendations. The following day, the DEC group accompanied GEA and GTCP team members on their morning patrol. While no turtle activities were witnessed at the time, the group observed and experienced the unique field conditions at Gnaraloo.

At the end of the onsite monitoring period, Mr. Boureau and Ms. Duffy spent approximately 2 weeks in Geraldton, from 13 February - 1 March 2011, to work directly under the guidance of GEA for review of seasonal data analysis and reporting. The final report 2010/11 will be widely distributed upon completion to contribute to baseline and knowledge of the Gnaraloo sea turtles.

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8. NEW GTCP COMPONENTS 2010/11

Gnaraloo's Environmental Advisor and the GTCP team 2010/11 undertook and completed a wide range of activities during the season to improve, strengthen and further develop the program and expand the scope of research, including the actions listed below.

8.1 Trend analysis of turtle activities

The GTCP Team Leader 2010/11 was appointed the task of managing and analysing informal data collected by a community member over a period of 5 years prior to and independently of the GTCP. A trend analysis of turtle activities in the Gnaraloo Bay Rookery was carried out, inclusive of the 5 years of informal data by the community member and 3 years of formal data by the GTCP. Advice, opinion, technical and statistical assistance were sought from experts in the field, including Dr. Mark Hamann (James Cook University) and Dr. Beth Fulton (CSIRO). The trend analysis provided valuable information on issues such as the temporal variation of the annual Loggerhead nesting season (start, peak and end) over a longer term period (refer Chapter later).

8.2 Verification of data through Night surveys

Track monitoring by itself only may result in data inaccuracies and errors. Given the need for a more reliable method for turtle species identification and determination of successful nesting attempts, the GTCP team undertook Night surveys during 2010/11 to improve data quality, accuracy and reduce the margin of error (refer Chapter later).

8.3 Crab burrow surveys

The GTCP team carried out additional research on crab populations along the Gnaraloo Bay Rookery, in order to investigate the relationship between turtle and crab species within the study area. Surveys of crab burrow density and spatial distribution (vertical and horizontal) were carried out fortnightly along the Study Area 2010/11 (refer Chapter later), followed by the production of a GIS map with results (refer Maps).

The crab burrow surveys may be undertaken throughout the year at Gnaraloo outside of the annual Loggerhead nesting season, in order to provide more comprehensive data sets. Gnaraloo's Environmental Advisor and GTCP researchers 2010/11 prepared a preliminary budget which was

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released to James Cook University during February 2011, to quantify the cost of repeating such survey work outside of the annual nesting season.

8.4 Community engagement

The GTCP was expanded during 2010/11 to include a community volunteer component. Under the guidance and co-ordination of Gnaraloo's Environmental Advisor, the GTCP Volunteer Co-ordinator designed, developed and managed the new volunteer program, including advertising the opportunity for participation and onsite management of all community volunteers. Refer to:

http://www.facebook.com/home.php?#!/notes/gnaraloo-turtle-conservation-program/volunteer-opportunity-come-and-help-us/160712770646172

The pre-season work on this component also involved development and set-up of the required linkages between monitoring work and research carried out by the GTCP scientific team and support activities by community volunteers.

Specifically, program development for community inclusion included:

- **Design and set-up of the volunteer program (pre-season):** Prior to 2010/11, community engagement with the GTCP was informal, lacking a structured managed program and procedures for volunteer participation. In order to ensure a professional, organised and environmentally responsible approach to community participation with the GTCP, a community volunteer program was developed during 2010. This involved pre-season design, development and refinement of the program model, structure, plans, a wide range of documents and advices by Gnaraloo's Environmental Advisor and the GTCP Volunteer Co-ordinator during an offsite work period in Geraldton. This included:
    - A range of options for the volunteer program (with advice on the educational opportunities, proposed volunteer activities, suggested schedules and complementary program activities, volunteer requirements and maximum volunteer group sizes, onsite accommodation and facilities, logistical arrangements, timing and cost). Based on review and feedback received from the Gnaraloo leaseholder and Gnaraloo management teams (onsite and Perth), package options were finalized and released to interested parties and groups for individual, group and schools participation with the GTCP.

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- A GTCP Community Volunteer Advertisement, which was distributed locally (including the Carnarvon Visitor Centre), nationally (at various universities and online notice boards for volunteering) and internationally (via online job boards).
- A PowerPoint presentation for community volunteers, including sea turtle biology, conservation, threats, scope of research under the GTCP, the role of community volunteers in the field and expected code of conduct for turtle watching whilst onsite at Gnaraloo. This was used through-out the season by GTCP researchers 2010/11, with a presentation to volunteers on the evening prior to their first participation with morning patrols.
- A GTCP Volunteer Log (paper and electronic) and Indemnity Form, documenting details such as participant's name, age, nationality and contact.
- A GTCP Facebook page to allow for more interactive information exchange with the community (refer below).

- **Participation by educational groups (pre-and-during season):** During October 2010, the GTCP Volunteer Co-ordinator contacted high schools in Carnarvon, Geraldton, Perth and Bunbury to establish linkages with interested schools and invite them to participate with the program during the season. The aim was to host groups comprising of Year 11 and 12 students (older than 15 years) for educational field excursions, with proposed morning participation in GTCP patrols and supervised afternoon activities in marine sanctuary zones along Gnaraloo's coastline (such as 3Mile Lagoon and/or Gnaraloo Bay) designed for exposure to and increased knowledge of the marine environment, biodiversity and conservation. The following set of documents were developed as part of this:
  - A 3 - 5 day educational package proposal for consideration by school principals, science and biology teachers and school trip organisers. Based on review and feedback received from the Gnaraloo leaseholder and Gnaraloo management teams (onsite and Perth), the schools package was finalised and externally released to interested schools.
  - A GTCP Schools Advertisement, which was distributed to targeted schools (refer Attachments).
  - A PowerPoint presentation for schools (similar to the one for community volunteers).
- **Participation by external volunteering organisations (pre-and-during season):** External volunteering organisations, such as Earthwatch and Volunteering WA, were contacted prior to and during the season 2010/11 and invited to participate with the GTCP. This has not yet yielded any definitive results.
- **External University turtle research projects (pre-and-during season):** Liaison, planning and co-ordination occurred with 2 external universities for additional separate sea turtle

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research projects (both BSc. Honours) at Gnaraloo during 2010/11, namely the University of Western Australia (**UWA**) and James Cook University (**JCU**), Queensland. Gnaraloo provided advice to ensure co-ordination of the GTCP, UWA and JCU research. It also developed several documents to assist the external turtle research teams, facilitate their field work, ensure consistency and compliance with site protocols. This included:

- A range of options, alternatives and recommendations for support during night based patrols by university researchers (depending on the extent of required patrolled area and patrol coverage). Included in this were benefits and costs to volunteers acting as 'turtle spotters', details of the sub-sections and lay-out of the Gnaraloo Bay Rookery, required resources, tide regimes and other comments.
- Advice and assistance, when required, to external researchers during their onsite research activities by the GTCP team 2010/11.
- A draft code of conduct for external researchers concerning movement, light and noise on the beach during night patrols in line with GTCP beach monitoring protocols.

- **Onsite management of community volunteers (during season):** During 2010/11, the GTCP Volunteer Co-ordinator's responsibility included the organisation and management of all volunteer queries, onsite arrival and participation with the program, in conjunction with Gnaraloo booking managers onsite and Perth. The GTCP Volunteer Co-ordinator ensured responsible management and guidance of all GTCP volunteers while onsite. GTCP community volunteers were provided with general information about sea turtles and any specific queries and requests were addressed. Upon arrival, participants received the introductory GTCP Community Volunteer PowerPoint presentation and were briefed on daily activities. Volunteers were offered an insight into field based turtle research and monitoring techniques during participation with the daily morning patrols.

Overall the new community volunteer component of the GTCP was successfully undertaken during 2010/11. The model and procedures designed for management of the component is deemed suitable for continuation and further development during future years. Outcome and results included:

- **Number of participants:** From 24 November 2010 - 30 January 2011, 26 community volunteers participated with the GTCP. The program hosted several diverse groups, from individuals to groups varying in size from 2 – 15 people. The age of volunteers ranged from 9 – 63 years, participation extended from 2 – 10 days and various nationalities participated, including Australian, British, American and South African. The largest group that participated with the program comprised of 15 adults and children.

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- **High schools:** Several high schools displayed an interest in organising educational excursions to Gnaraloo during the monitoring period 2010/11, however time constraints did not allow for participation during 2010/11 for the majority of schools contacted. The GTCP Volunteer Co-ordinator liaised with Nagle Catholic College in Geraldton, Western Australia, and arranged for 18 students and 2 teachers to participate with the program, for 5 days from 24 – 28 January 2011. Unfortunately the school was not able to attend and cancelled 5 days prior to the arranged arrival onsite due to logistical issues on their part. Gnaraloo's Environmental Advisor liaised and met with the school in Geraldton to make alternative arrangements for the school's inclusion in the program during 2010/11. Consequently, on 17 February 2011, Gnaraloo's Environmental Advisor and GTCP team members gave a presentation on the program to 26 students and 2 teachers. Gnaraloo is making arrangements for the school's future attendance and participation with the GTCP during 2011/12.
- **Carnarvon PCYC:** The GTCP hosted a 6 person group from Carnarvon PCYC on 29 January 2011. Members of the group accompanied GTCP researchers during their morning patrol. The PCYC group helped with nest data collection and learnt about turtles, their behaviour and the need for protection efforts.
- **Positive feedback:** The GTCP received strong positive feedback from volunteers for their involvement, including in writing.

8.5 GTCP on the web

The GTCP team 2010/11 developed a Facebook page for the program to reach a wider sector of the public and visitors to Gnaraloo and provide less scientific information than currently available on the Gnaraloo website (www.gnaraloo.com) where the seasonal reports are published.

The GTCP Facebook site provides updates on program activities and events, in the form of notes, field diaries, significant site events, research activities, opportunities for volunteer participation as well as information on marine and terrestrial biodiversity at Gnaraloo. A large photo database was also created and posted on the site.

Refer to:

http://www.facebook.com/pages/Gnaraloo-Turtle-Conservation-Program/108817312525609

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Preliminary work was undertaken to re-design the GTCP section of the Gnaraloo website (including a suggested new webpage lay-out, design and text). As this has not yet been completed, it needs to be further developed and completed during 2011/12 (refer Recommendations).

8.6 Additional training and reference materials

To complement the training received in Exmouth, the GTCP team 2010/11 developed additional training material specifically on Gnaraloo Loggerhead (*Caretta caretta*) turtles to assist the familiarisation of future GTCP teams with Loggerhead track patterns as well as distinctive characteristics of various Loggerhead beach activities. This was done to reduce margins of error, particularly at the start of the nesting season when researchers are not yet familiar or experienced with this species. A database with photos of turtle tracks, nests, unsuccessful nesting attempts (**UNAs**), U Tracks as well as eroded and predated nests is contained within the *GTCP Monitoring Procedure 2010/11* (Hattingh *et al*., 2011). All photographs were from morning patrols during 2010/11.

GTCP researchers also created a new program flash-drive, the 'Turtle Key', for use by future GTCP teams. This contains electronic GTCP program information, templates, monitoring forms, databases, reports, training materials, reference documents, maps and photos.

8.7 Further development of monitoring forms, procedure, data bases

The GTCP team 2010/11 further developed the draft GTCP Monitoring Procedure 2009/10 and completed update of and detail on data collection procedure and protocols to ensure data quality, consistency and replication from year to year.

The GTCP Day Monitoring Form 2009/10 and GTCP Night Monitoring Form 2009/10 were also updated to reflect the altered scope of research during 2010/11 and specific beach conditions and species activities within the study area.

The format, lay-out and contents of *GTCP Excel Databases* were also updated, including to enable required linkages between data monitoring forms and database entries.

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8.8 Improved mapping

The GTCP GIS Cartographer used the newly acquired high resolution aerial photograph of Gnaraloo Station sourced from Department of Environment and Conservation (Exmouth), the shapefile provided by CSIRO and the ArcGIS software provided by Esri Australia to undertake essential spatial analysis during 2010/11 to produce higher quality maps than previously possible of turtle activities, crab burrow density and distribution in the Gnaraloo Bay rookery.

8.9 Turtle and fox information flyer and signs

During 2010/11, Gnaraloo produced an information flyer for public distribution (onsite, offsite and online) with information on the GTCP and Gnaraloo Fox Control Program. New site signage was also developed, with information for visitors about impacts of turtles and responsible behaviour on beaches.

Refer to:

http://www.facebook.com/notes/gnaraloo-turtle-conservation-program/gtcp-information-flyer-200910/167630643287718

and

http://www.facebook.com/notes/gnaraloo-turtle-conservation-program/gtcp-sign-201011/167631379954311

8.10 Research on turtle foraging and/or resting sites at Gnaraloo

As Gnaraloo guests and visitors have repeatedly reported observations of sea turtles in Gnaraloo waters outside of the annual breeding season, GTCP researchers 2010/11 developed advice for guests, including a '*Turtle Identification Key*', specifically tailored to assist them to identify turtle species. It includes information on simple defining characteristics, such as the shape of the shell and head of different turtle species. A log titled 'Turtle sightings in Gnaraloo waters' was also created, along with information notices displayed at the reception areas and shops at the Gnaraloo Homestead area and 3Mile Camp, which encourage guests and visitors to notify Gnaraloo staff whenever they see turtles in the water. It also requests copies of any photos or video footage of turtles observed in the water. This is hoped to provide additional basic information for possible

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future in-water surveys to establish the presence of possible turtle foraging and/or resting sites at Gnaraloo (refer to Recommendations).

8.11 Recognisance of the additional Gnaraloo rookery

GTCP team members 2010/11 carried out a recognisance trip of the northern most rookery at Gnaraloo, Gnaraloo Northern Rookery, on 12 January 2011, in order to investigate ease of access, feasibility of possible future monitoring and possible locations for a support out-camp for turtle researchers (refer to Recommendations).

8.12 Data sharing with international turtle databases

Data collected during 2010/11 will be released to the *State of the World's Sea Turtles* (**SWOT**) and to the *Indian Ocean – South East Asian* (**IOSEA**) marine turtle memorandum of understanding for posting on their international databases so that researchers external to Gnaraloo may access, share and use the information.

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9. TREND ANALYSIS OF NESTING ACTIVITY OVER 8 YEARS

9.1 Objectives

The objectives of the trend analysis were:

- Identify trends in turtle nesting activities in the Gnaraloo Bay Rookery.
- Identify the average start, peak and end of the annual nesting season in the Gnaraloo Bay Rookery.
- Make use of informal data records (2000 – 2008) on turtle activity in the Gnaraloo Bay Rookery that had not previously been recorded electronically nor analysed.
- Provide valuable information for planning and further development of the GTCP in future.

Refer to the section titled 'Introduction' for an overview and more detailed information of the objectives of the GTCP.

9.2 Monitored area

Throughout the years of informal and formal monitoring, research was carried out in the Gnaraloo Bay Rookery located between -23.76708° / 113.54584° and - 23.72195° / 113.57750°. It consists of a mix of the calm, static beaches of Gnaraloo Bay to the dynamic beaches and mobile dune systems extending 6.7km northwards.

9.3 Materials and methods

Electronic entry and analysis of informal data records (2000 – 2008)

Electronic records were created of hand written data collected by a community member (refer Reference list) over a 5 year period from 2000 - 2008 (i.e. 2000/01, 2001/02, 2002/03, 2005/06 and 2007/08), **prior to and independently of the GTCP**. A large amount of data such as field records, reports, informal communications, photos and maps were analysed in order to extract any valuable and useful information. This information was entered into an Excel database called '*Gnaraloo Turtle Informal Data Records 2000 – 2008'*.

The following number of data sets (at 3-day interval periods) was available for each year:

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- 2000/01: 18 data sets;
- 2001/02: 24 data sets;
- 2002/03: 34 data sets;
- 2005/06: 3 data sets;
- 2007/08: 2 data sets.

Given inconsistency in the data sets (in terms of data collected and amount of time spent in the field each season), it was decided that only data on the **temporal distribution of Loggerhead (*Caretta caretta*) nesting activity** (i.e. the beginning, peak and end of the annual Loggerhead nesting season) **were valuable for further analysis**. Data such as number of nests per season, incubation period, geographical position of nests, disturbance/predation by native and introduced species were considered to be too inconsistent to be taken into consideration or further analysed.

The informal data sets (i.e. 2000 – 2008) were then analysed with the GTCP formal data sets (i.e. 2008 - 2011) in order to produce a trend analysis of Loggerhead nesting activities within the Gnaraloo Bay Rookery over 8 years. Opinion, technical and statistical assistance and advice were sought from experts in the field, including Dr. Mark Hamann (James Cook University) and Dr. Beth Fulton (CSIRO).

9.4 Results

As Figures 1a and 1b demonstrate, the different sets of data follow a normal (or Gaussian) distribution.

By calculating the mean and standard deviation for the date when the number of nests dug is >3 (an arbitrary threshold chosen to define the beginning of the season, following the advice of CSIRO statistician, Dr. Beth Fulton), it can be confirmed that **the nesting season at the Gnaraloo Bay Rookery begins around 17 November**.

Then, **nesting activities in the Gnaraloo Bay Rookery increase steadily to reach a peak in January**. When calculating the point of central tendency of each distribution (i.e. when half of the nests of the season have been seen), it is possible to see a significant shift in phenology (timing) through the season over 8 years of data. **This shift occurs generally around 10 January**.

Finally, the nesting activity follows a decreasing curve until the end of the nesting season. By calculating the mean and standard deviation for the date when the number of nests dug is <3 (an

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arbitrary threshold chosen to define the end of the season), it can be confirmed that **the nesting season at the Gnaraloo Bay Rookery generally ends around 22 February**.

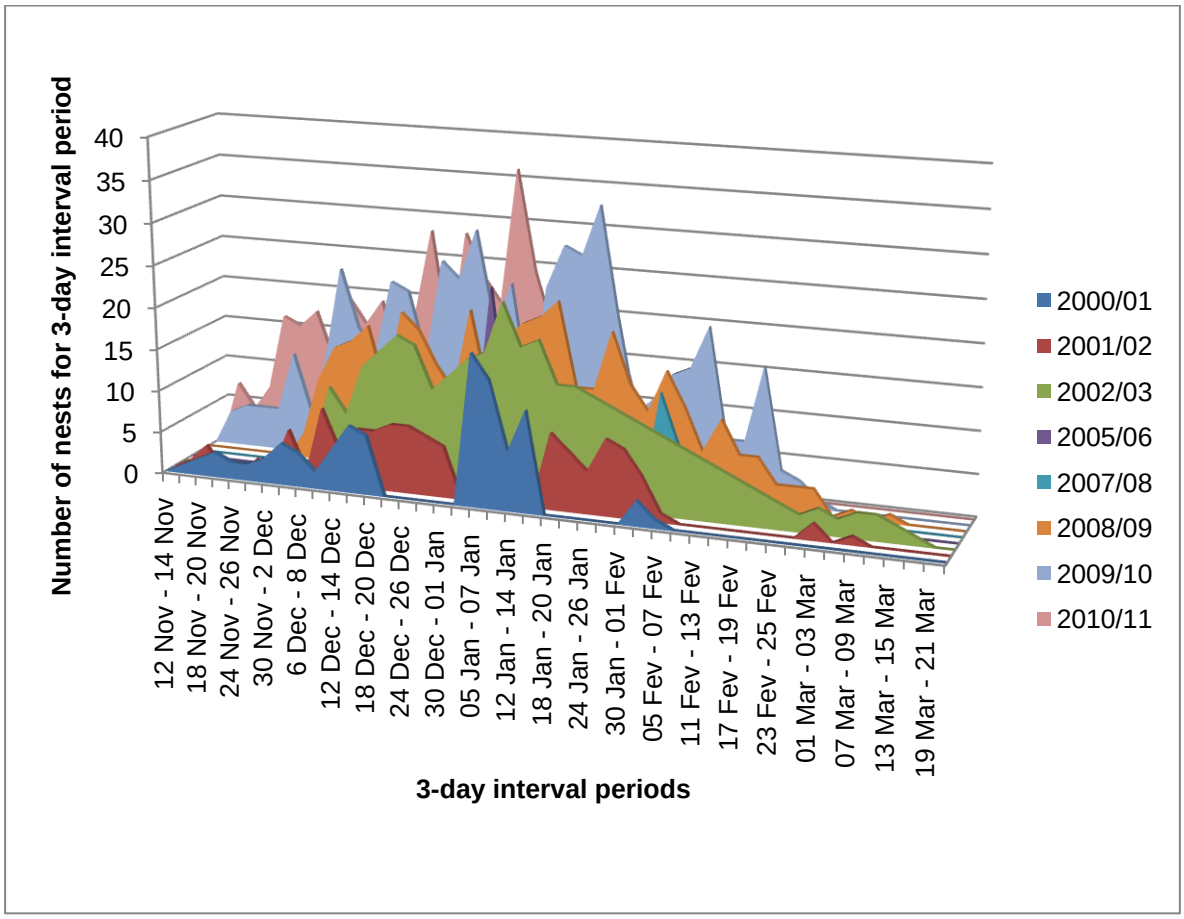

Figure 1a: Temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 – 2011) (3D representation)

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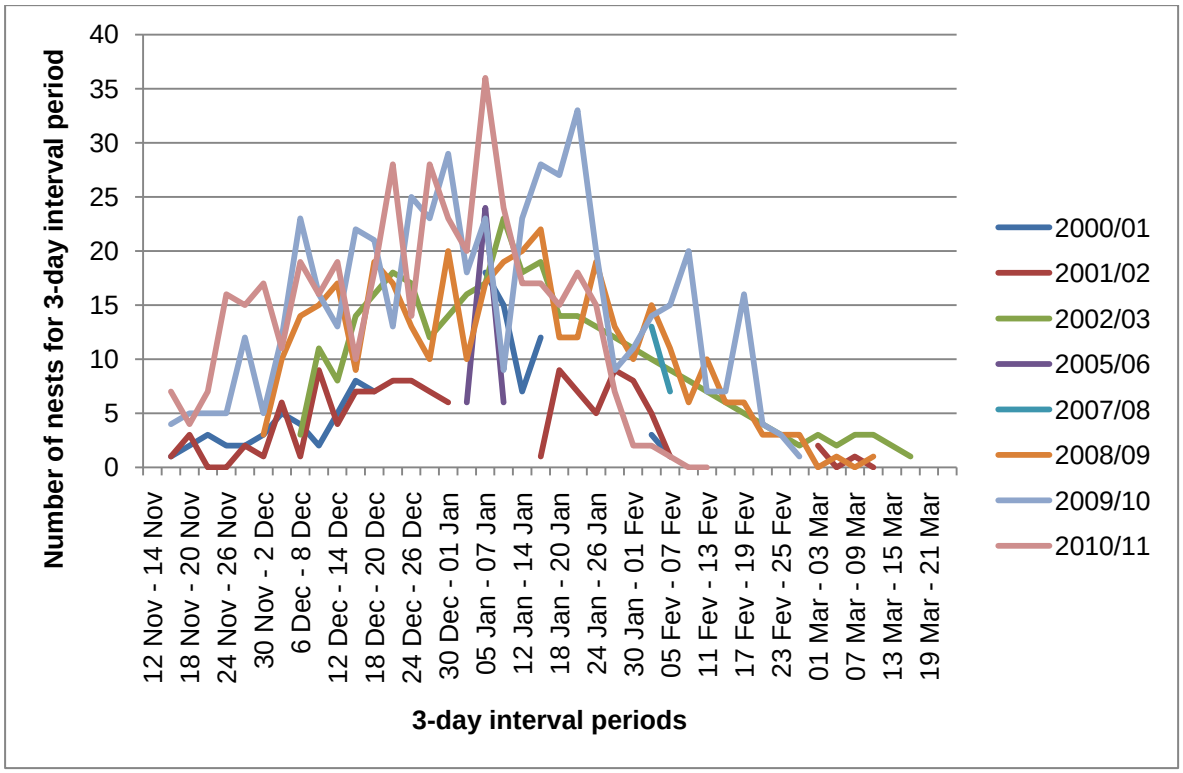

Figure 1b: Temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 – 2011) (Line graph representation)

As can be seen in Figure 2 below, the polynomial trendline of the temporal distribution of Loggerhead nests (at 3 day interval periods) over 8 years follows the same normal distribution. Using the mean and standard deviation for the date when the number of nests dug reach the arbitrary thresholds previously defined (i.e. >3 for the beginning of the season and <3 for the end of the season), it is now easier to see the evolution of the nesting activity and to define the beginning (around 17 November) and the end of the breeding season (22 February). The peak of the season (i.e. point of central tendency of each distribution when half of the nests of the season have been seen) is again confirmed around 10 January.

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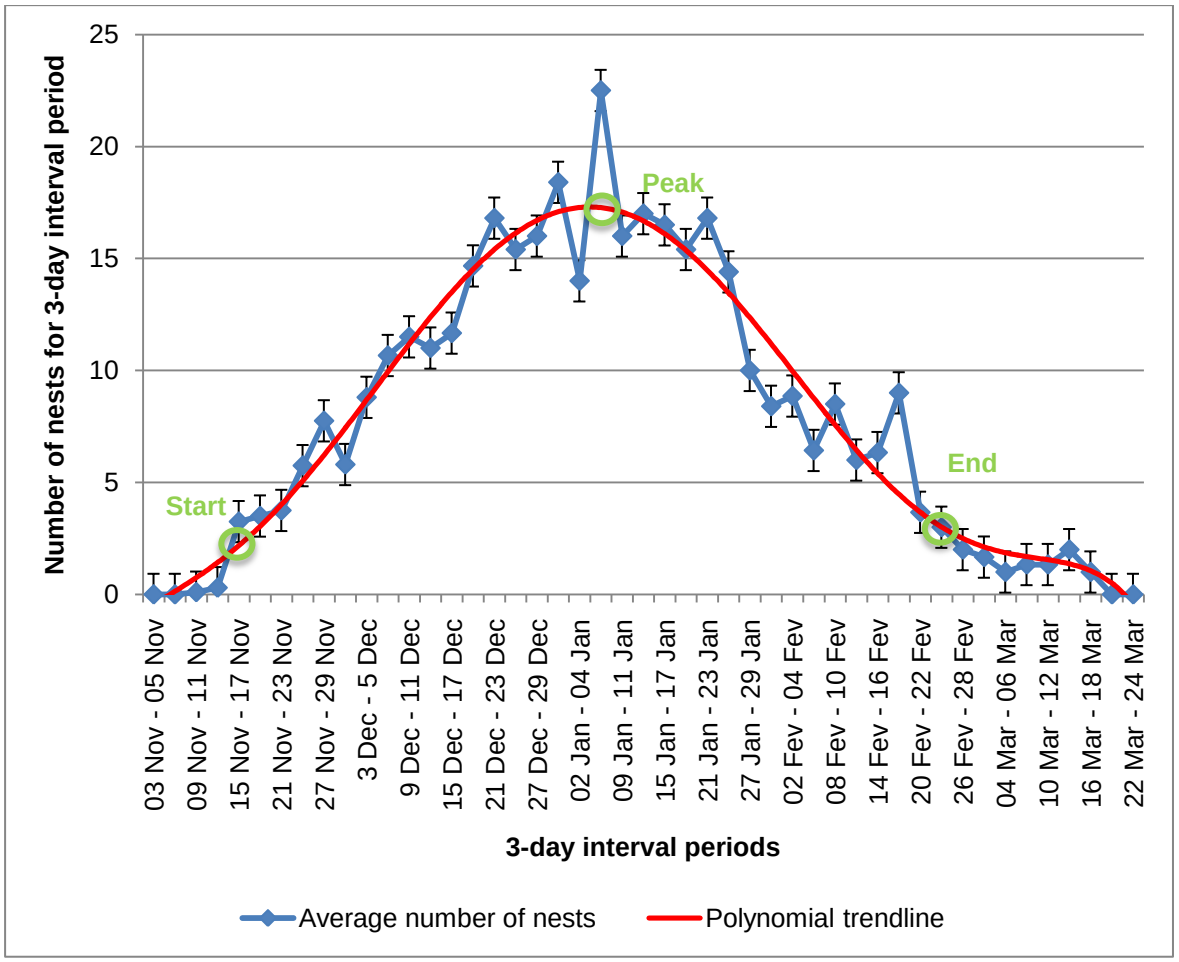

Figure 2: **Polynomial trendline of temporal distribution of Loggerhead (*Caretta caretta*) nests at 3-day interval periods over 8 years (2000 - 2011)**

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9.5 Discussion

Temporal distribution of Loggerhead nesting activity over 8 years

A clear temporal distribution pattern has been highlighted based on 8 years of data (informal and formal) and 3 fundamental moments of the annual Loggerhead nesting season at the Gnaraloo Bay Rookery have been defined as follows:

- **Start of the nesting season:** when the number of nests dug within the monitored area is >3. The start of the nesting season was confirmed around 17 November.
- **Peak of the nesting season:** when half of the total number of nests dug within the monitored area has been seen. The peak of the nesting season was confirmed around 10 January.
- **End of the nesting season:** when the number of nests dug within the monitored area is <3. The end of the nesting season was confirmed around 22 February.

Data integrity

Given the inconsistency in the informal data sets prior to the GTCP (in terms of data collected and amount of time spent in the field each season), it is recommended that a statistical study be again undertaken in future (e.g. after 5 years of formal GTCP monitoring) in order to confirm the temporal distribution of the Loggerhead nesting activity within the Gnaraloo Bay Rookery.

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9.6 Conclusions

Temporal distribution of Loggerhead nesting activity over 8 years

Given inconsistency in the informal data sets collected prior to and independently of the GTCP, analysis during 2010/11 only occurred of data from 2000 – 2008 on the temporal distribution of Loggerhead (*Caretta caretta*) nesting activity. Data from 2000 – 2008 on number of nests per season, incubation period, geographical position of nests, disturbance/predation by native and introduced species were too inconsistent to be taken into consideration or further analysed.

From a management point a view, it is fundamental to identify and clearly define the temporal evolution and stages of the annual Loggerhead nesting season at the Gnaraloo Bay Rookery in order to provide required valuable information. The trend analysis undertaken during 2010/11 of 8 year's worth of data (i.e. 5 years of informal monitoring prior to the GTCP and 3 years of formal monitoring under the GTCP) provided important and essential information on the temporal distribution of annual Loggerhead nesting activity within the Gnaraloo Bay Rookery, defining the start, peak and end of the season (i.e. annually around 17 November, 10 January and 22 February).

It is recommended that a statistical study be again undertaken in future (e.g. after 5 years of formal GTCP monitoring) in order to confirm the temporal distribution of the Loggerhead nesting activity within the Gnaraloo Bay Rookery. Besides, other fundamental questions could not be answered during 2010/11, including:

- dominant turtle species nesting within the study area;
- average number of nests per season;
- incubation period;
- percentage disturbance and/or predation by native and introduced species.

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10 DAY MONITORING 2010/11

10.1 Objectives

The objectives of the Day monitoring program during the annual nesting season 2010/11 (for the period of nest digging only) were:

- Collect data of sea turtle beach activities in the Gnaraloo Bay Rookery through daily track monitoring.
- Monitor the distribution trends of turtle species in the Gnaraloo Bay Rookery.
- Collect data on disturbance and predation of turtle nests (eggs and hatchlings) by introduced and native predators in the Gnaraloo Bay Rookery.
- Include volunteers and the community through onsite education and involvement with the GTCP.

Refer to the section titled 'Introduction' for an overview and more detailed information of the objectives of the GTCP.

10.2 Monitored area

Monitoring was carried out in the Gnaraloo Bay Rookery (refer Maps), located between -23.76708°/113.54584° and - 23.72195° / 113.57750°, during the season 2010/11.

10.2.1 Summary of Study Area 2010/11

The Study Area 2010/11 consisted of the calm, static beaches of Gnaraloo Bay to the more dynamic beaches and mobile dune systems extending 6.7km northwards. The established sub-sections within the monitored rookery lie adjacent to one another and are cordoned off by permanent Beach Point Markers (refer below).

10.2.2 Permanent Beach Point Markers

The Permanent Beach Point Markers consist of 5 stationary markers that are affixed well above the high water mark and that remain in place from season to season. These markers are a mix of PVC pipes and star pickets, with the exception of the Gnaraloo Bay North (**GBN**) marker. The latter denotes the southernmost point of the study area and comprises of the large yellow *Ningaloo Marine Park* (**NMP**) sanctuary pole.

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10.2.3 NEW GBN – BP7

Gnaraloo Bay North to Beach Point 7 (**GBN - BP7**) is a new sub-section that was created during 2010/11. The decision to group the previous sub-sections GBN – Beach Point 6 (**BP6**) and BP6 – BP7 to form the new GBN – BP7 was made given the low number of activities recorded specifically within the historical GBN - BP6 sub-section.

The new GBN - BP7 sub-section is the southernmost sub-section of the total study area. It is located between the 2 Permanent Beach Point Markers: GBN (-23.76708° / 113.54584°) and BP7 (-23.75001° / 113.56871°). The Permanent Beach Point Marker at BP7 is a white PVC pipe affixed atop a fore dune.

The new GBN - BP7 sub-section is 2.35km as the crow flies and can be covered on foot in approximately 1 hour.

10.2.4 BP7 – BP8

Beach Point 7 – Beach Point 8 (**BP7 - BP8**) is located between -23.75001° / 113.56871° and -23.73631° / 113.57448°. The Permanent Beach Point Marker at BP8 is a white PVC pipe that sits atop a fore dune.

The BP7 – BP8 sub-section is 1.63km and can be covered in approximately 30 minutes on foot.

10.2.5 BP8 – BP9

Beach Point 8 – Beach Point 9 (**BP8 - BP9**) is northerly adjacent to BP7 - BP8. It is located between the coordinates -23.73631° / 113.57448° and -23.72195° / 113.57750°. The Permanent Beach Point Marker at BP9 is a star picket atop a small dune, inside the vegetation.

The BP8 – BP9 sub-section is 1.72km and takes about 30 minutes to walk.

10.3 Materials and methods

The equipment used and methodology employed during the monitoring season 2010/11 are described in the *GTCP Monitoring Procedure 2010/11 (*Hattingh *et al*., 2011*).*

The monitoring season 2010/11 was ended on 7 February 2011 due to a near cessation of turtle beach activities from 31 January 2011 onwards. GTCP researchers 2010/11 ended the monitoring

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work earlier than anticipated in order to concentrate their efforts on the development and completion of the season-end report and monitoring procedure.

10.4 Results

10.4.1 Track monitoring

During the monitoring season 2010/11, a total of 426 nests were recorded within the Gnaraloo Bay Rookery (refer Figure 3 below).

Loggerhead (*Caretta caretta*) turtle nests were predominantly recorded in the Study Area 2010/11. In total (refer Figures 3 and 5), out of the 426 nests dug during the monitoring period:

- Loggerheads accounted for 402 nests;
- Greens (*Chelonia mydas*) for 8 nests;
- Hawksbills (*Eretmochlys imbricata*) for 2 nests;
- 14 nests were unable to be identified due to track erosion by the wind or tide fluctuations.

After the onsite work ended, given the difficulty of accurately identifying Hawksbill tracks compared to Loggerhead tracks in the field, GTCP researchers 2010/11 sent photos of the 2 Hawksbill tracks and nests recorded during the season (refer Photo Plates) for peer advice and review to specialists in the field, including Dr. Bob Prince (DEC Perth), who himself sought a second opinion on the tracks, and Dr. Mark Hamann (James Cook University, Queensland). They confirmed that at least 1 of the 2 sets of tracks was from a Hawksbill and that the other was equivocal as to whether it was a Hawksbill or possibly a small Loggerhead. As a result, to be conservative, **the number of Hawksbill females** recorded for the monitoring season 2010/11 was noted as at least 1.

During the monitoring period, 799 tracks were recorded in the Study Area 2010/11, including nests, Unsuccessful Nesting Attempts (UNAs) and U Tracks (refer Figure 3).

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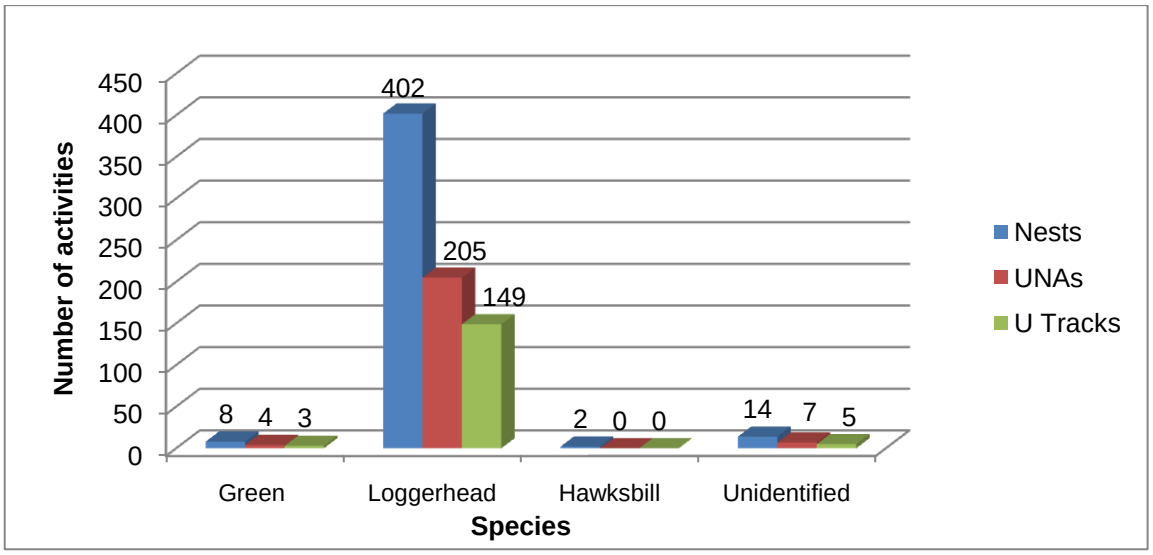

Figure 3: Total number of Nests, UNAs and U Tracks per species within Study Area 2010/11 (13/11/10 – 07/02/11)

Figure 4 shows that out of the 799 tracks recorded in the Study Area 2010/11:

- 426 (53.32%) were nests,
- 216 (27.03%) were UNAs; and
- 157 (19.65%) were U Tracks.

Consequently, approximately 1 out of 2 turtle beach activities within the Gnaraloo Bay Rookery during the nesting season 201011 resulted in a nest.

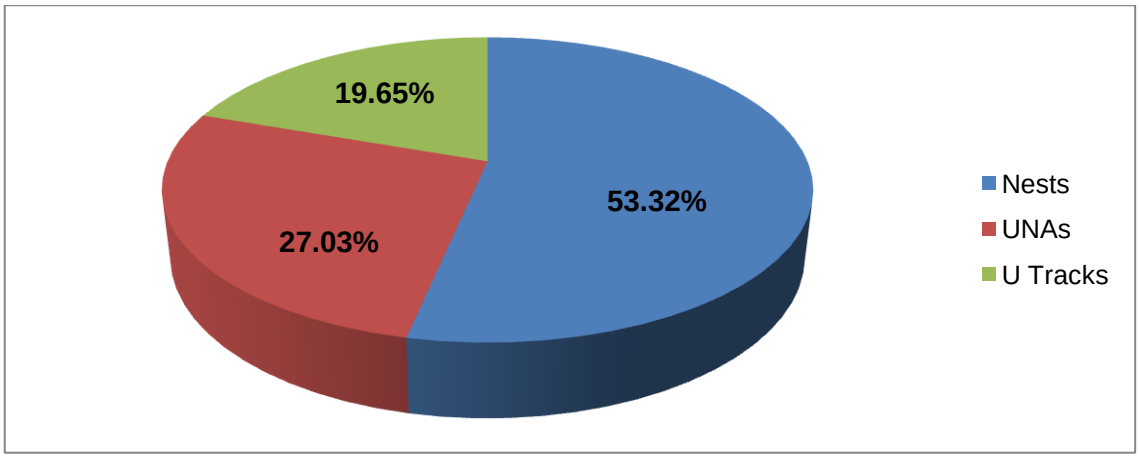

Figure 4: Percentage composition of all turtle beach activities within Study Area 2010/11 (13/11/10 – 07/02/11)

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As is shown in Figure 5, the Study Area 2010/2011 was predominately nesting Loggerhead turtles (*Caretta caretta*). In total, Loggerheads accounted for 402/426 nests dug (94.36%), followed by small percentages of Green turtles (*Chelonia mydas*) with 8/426 nests dug (1.88%) and Hawksbill turtles (*Eretmochlys imbricata*) accounted for only 2/426 nests dug (0.47%). Out of 426 nests recorded, 14 nests (3.29%) were unable to be identified due to track erosion by the wind and tide fluctuations.

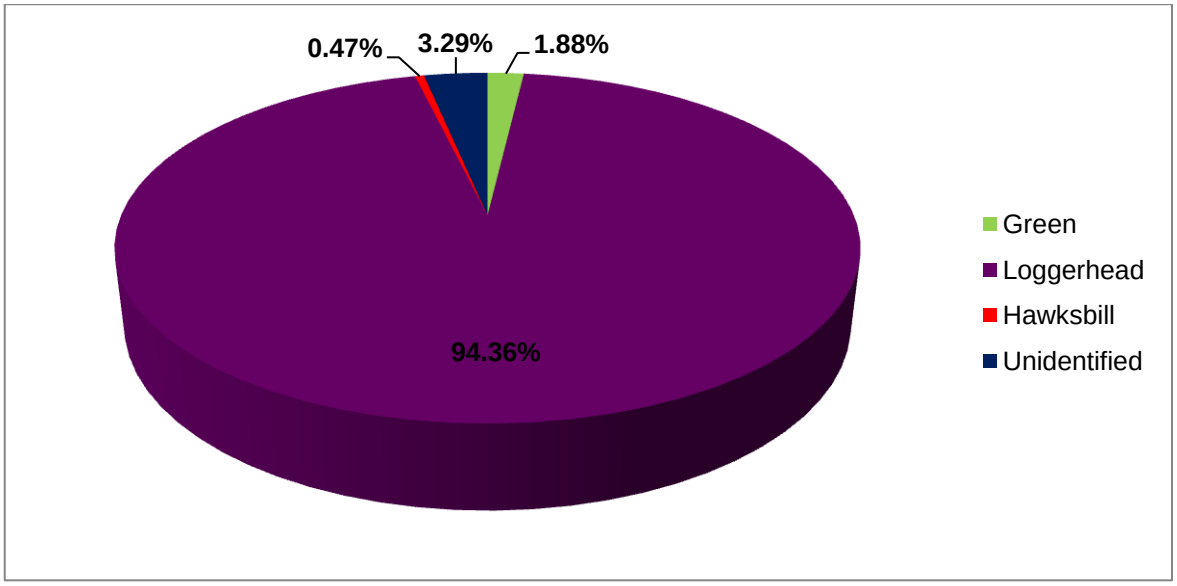

Figure 5: Species composition of recorded turtle nests within Study Area 2010/11 (13/11/10 – 07/02/11)

For a breakdown of nest distribution trends within the Gnaraloo Bay Rookery, please refer to Maps.

Given the dominant percentage of Loggerhead nests within the Study Area 2010/11 (around 94%), **only data concerning Loggerheads will be presented thereafter.**

As Figure 6 demonstrates, the peak in nesting activity during the season 2010/11 was witnessed in early January 2011. The number of Loggerhead nests increased slowly through the season to reach a maximum value of 16 nests on 5 January 2011. Nesting activity subsequently decreased, with 1 nest only being recorded on 4 February 2011. Onsite monitoring ended on 7 February 2011.

On a daily basis, the number of Loggerhead nests per day fluctuated notably, which is why a polynomial trendline provides a better analysis of the progression of the nesting activity.

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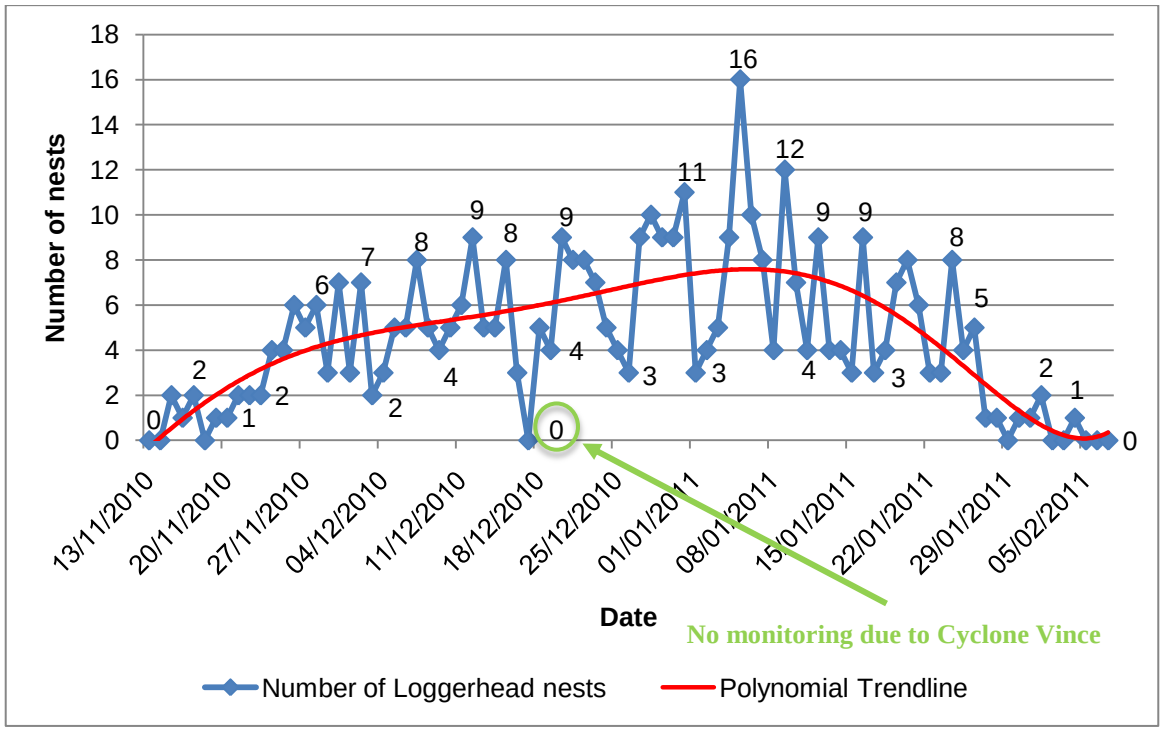

Note: Daily monitoring couldn't be carried out on 17 December 2010 due to impassable flooded roads after Cyclone Vince (16 – 17 December 2010, 237mm rain).

Figure 6: Daily Loggerhead (*Caretta caretta*) nest count within Study Area 2010/11 (13/11/10 – 07/02/11)

The number of nesting (female) turtles within a rookery can only be identified physically, by performing laparoscopic examinations (Limpus & Limpus, 2003) as well as by measuring curved carapace length (CCL) using a flexible fibreglass tape (Limpus *et al*., 2006). Additionally, observations of tagged turtles returning to nesting beaches are also used to count the number of breeding females. The GTCP team 2010/11 wasn't able to record such data as no formal night monitoring was carried out during the season.

As can be seen in Figure 7 below (blue line), the first nest was seen on 15 November 2010 during the monitoring season 2010/11 and increased to an average of 38 nests per week until late December 2010. Nesting frequency peaked at 64 nests per week during 3 - 9 January 2011 and then gradually abated throughout the remainder of the monitoring season. In the final week of monitoring, only 5 new nests were recorded, with the last nest being seen on 4 February 2011.

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Looking at the cumulative nest total line (refer red line in Figure 7), the slope rose sharply and continued to rise at a similar gradient from 15 November 2010 to 17 January 2011, indicating an increasing amount of nesting activity per week. Nesting activity then reduced considerably until 7 February 2011 when monitoring ended.

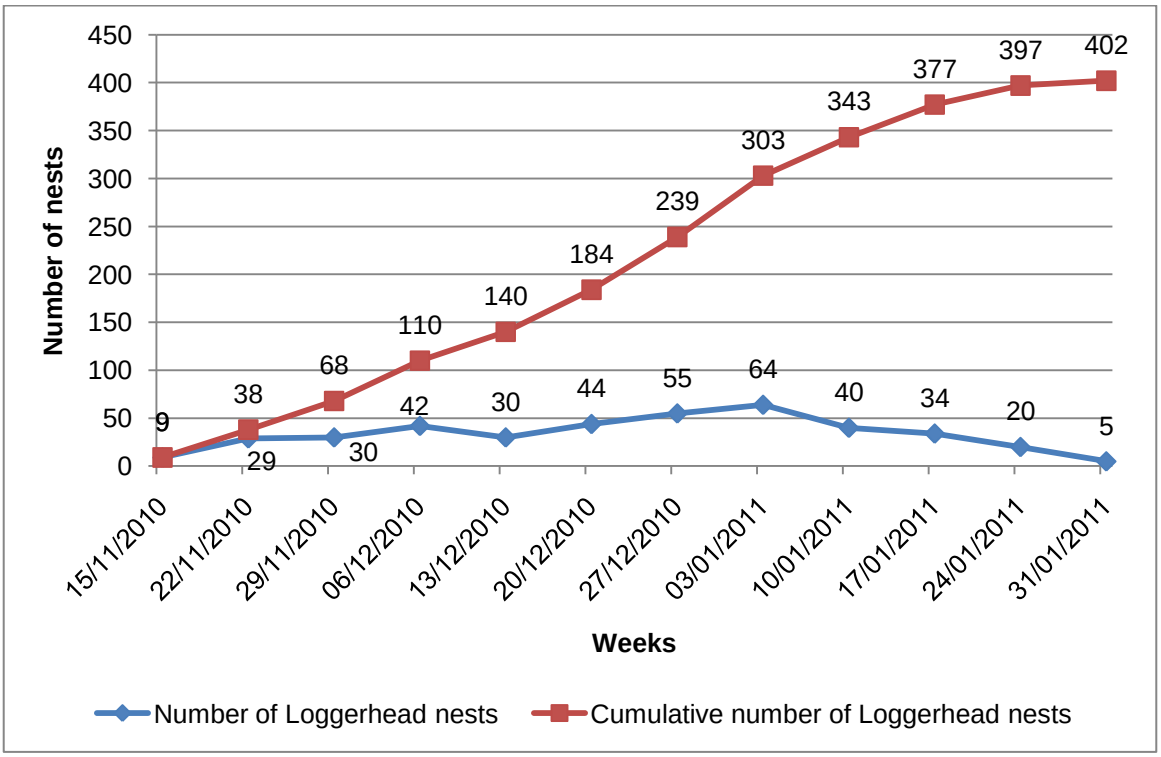

Figure 7: Progressive and cumulative number of Loggerhead (*Caretta caretta*) nests per week within Study Area 2010/11 (13/11/10 – 07/02/11)

As can be seen in Figure 8 below, turtle nesting activity in the Study Area 2010/11 occurred throughout the majority of the monitoring season. After the first recorded nest on 15 November 2010, nesting frequency (the blue line) steadily increased until the season's peak on 5 January 2011. Then, nesting frequency steadily decreased to only 5 new nests recorded in the final week of monitoring. Total Loggerhead activity per week (the purple line) within Study Area 2010/11 shows the combined nest, UNA and U Track activities (respectively the blue, red and green lines). Loggerhead UNA activities also peaked around 5 January 2011. Loggerhead U Track activities peaked the week of 27 December 2010.

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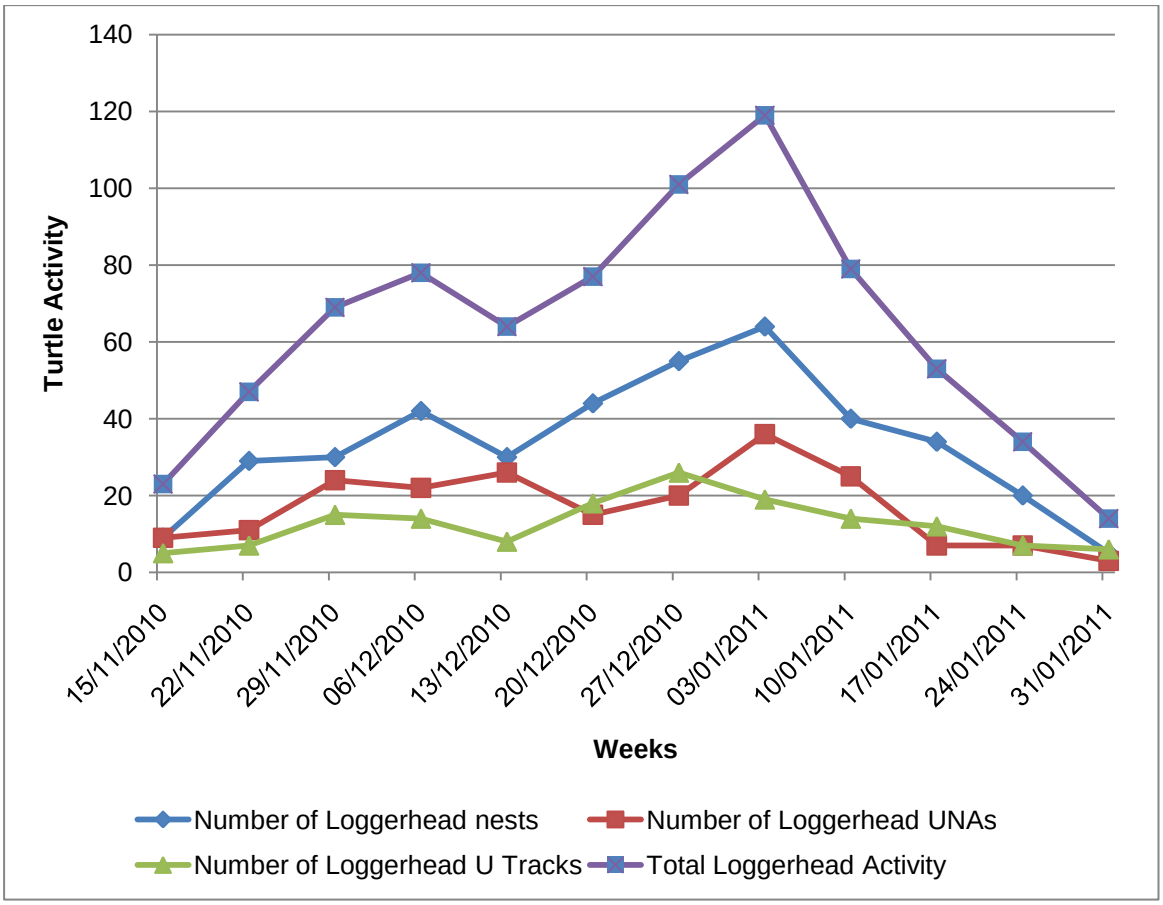

Figure 8: Total Loggerhead (*Caretta caretta*) beach activity per week within Study Area 2010/11 (13/11/10 – 07/02/11)

Turtle activities were predominantly recorded in the northernmost sub-section BP8 - BP9 (more than 60% of total season activity). As Figure 9 demonstrates, BP8 - BP9 was also a preferred nesting location for Loggerhead turtles (approximately 55% of the beach activities in this sub-section were nests). BP7 - BP8 was the lowest sub-section in terms of activities recorded and 32% of these activities corresponded to successful nesting attempts. More than 200 activities were recorded in the southernmost sub-section GBN - BP7, with an equal percentage of nesting (52%) and non-nesting (i.e. UNA and U Track) (48%) activities.

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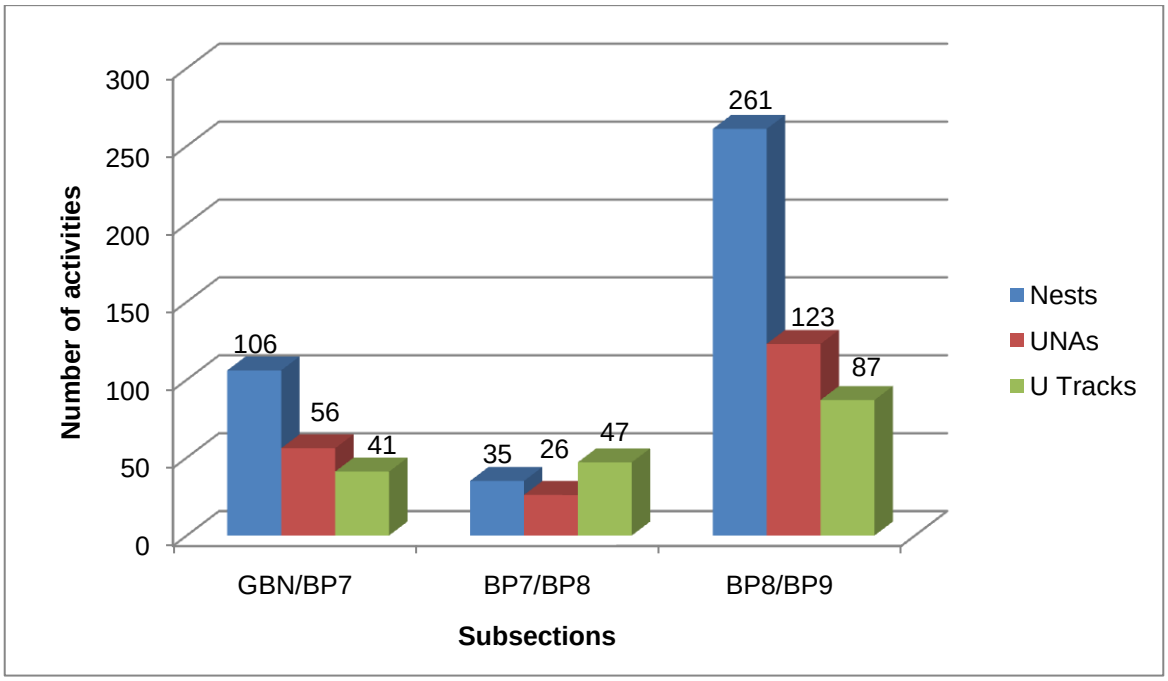

Figure 9: **Total number of Loggerhead (*Caretta caretta*) Nests, UNAs and U Tracks per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)**

10.4.2 Nest disturbances and predation by foxes

The monitoring season 2010/11 consisted of 87 sample days during 13 November 2010 – 7 February 2011. No fox tracks were recorded within Study Area 2010/11 during this time.

10.4.3 Nest disturbances by crabs

The Golden ghost crab (*Ocypode convexa*) is a native species that is common and abundant along the Gnaraloo coastline. Besides the Golden ghost crab, there are other species of Ghost (or Sand) crabs that were observed within the Study Area 2010/11. Running ghost crab (*Ocypode ceratophthalma*) was the only other species positively identified, but there is thought to be a minimum of 2 additional morphologically distinct but as yet unidentified species.

Both Golden ghost crab (*Ocypode convexa*) and Running ghost crab (*Ocypode ceratophthalma*) were observed to predate turtle hatchlings during the season 2010/11. None of the unidentified species were observed to predate the sea turtle nests, but it is recommended that further investigation be done in future to see whether or not this holds true.

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For the purpose of turtle monitoring, **disturbance** and **predation** by crabs were separately recorded (refer Glossary for the definitions).

The number of crab burrows recorded within turtle nests during the monitoring season 2010/11 ranged from 1 – 48 per nest.

As exhumations of turtle egg chamber are not currently being performed as part of the GTCP, without egg shells present at the surface, it cannot be determined from crab burrowing activity alone whether or not the crabs successfully reached an egg chamber or whether the burrowing was simply coincidental. Some nests with previous repeated crab **disturbances** were still observed to hatch during the Day monitoring season 2009/10, which indicates that the extent of any damage done by crabs to nests cannot be assessed from the surface only.

A total of 310/426 nests (73%) within the Study Area 2010/11 were recorded to be disturbed or predated by crabs during the monitoring season (refer Figure 10). A total of 149/426 nests (35%) were recorded to be disturbed and a total of 162/426 (38%) nests were predated by crabs.

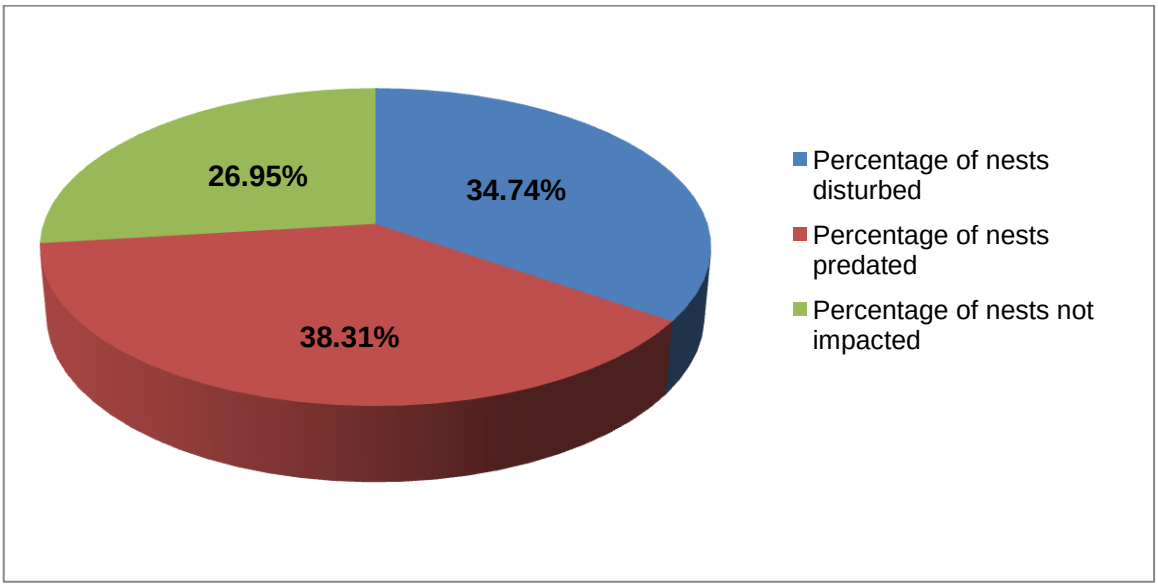

Figure 10: **Percentage of turtle nests disturbed, predated and not impacted by crabs within Study Area 2010/11 (13/11/10 – 07/02/11)**

Sub-section GBN – BP7 consisted of 106 Loggerhead nests, approximately 66% with observed disturbances (34%) and observed predations (32%) by crabs (refer Figure 11 and 12 below). This

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flat, stable beach is sheltered by the offshore fringing reef and has little environmental debris (e.g. seaweed) deposited on its shores.

Sub-section BP7 – BP8 had a relatively high percentage of crab disturbance and predation (76%) (refer Figure 12 below). With only 35 Loggerhead nests recorded in this sub-section, 36% of nests were disturbed and 40% were predated by crabs. This sub-section contains dynamic beaches and locations with high wave energy which produces soft sand and deposits a substantial amount of environmental debris onshore, providing food for crabs and sustaining their high population numbers here.

The northernmost sub-section of the Study Area 2010/11, BP8 – BP9, contained the majority of Loggerhead nests during the monitoring period, with 261 nests in total. Of those nests, 77% were recorded as disturbed (34%) or predated (43%) by crabs during the 87 sample days (refer Figure 11 and 12 below). This sub-section also contains dynamic beaches and locations with high wave energy.

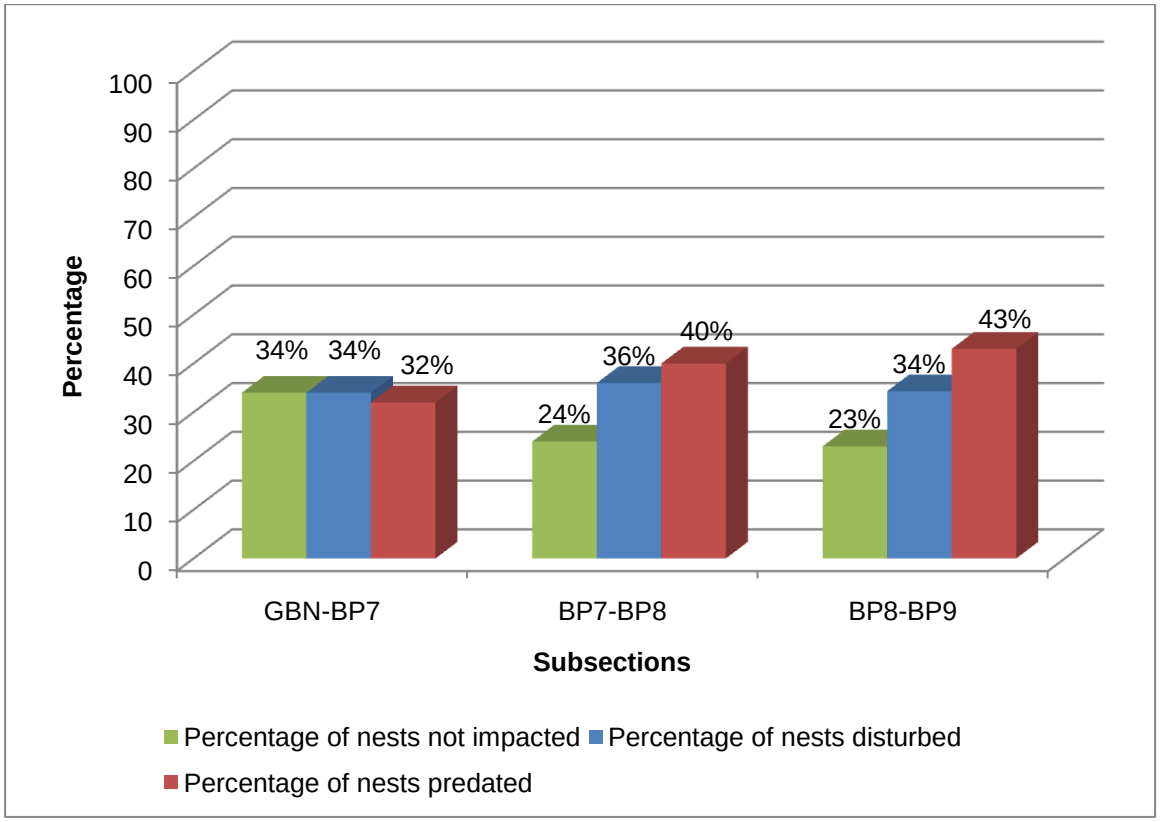

Figure 11: Percentage of Loggerhead (*Caretta caretta*) nests disturbed, predated and not impacted by crabs per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)

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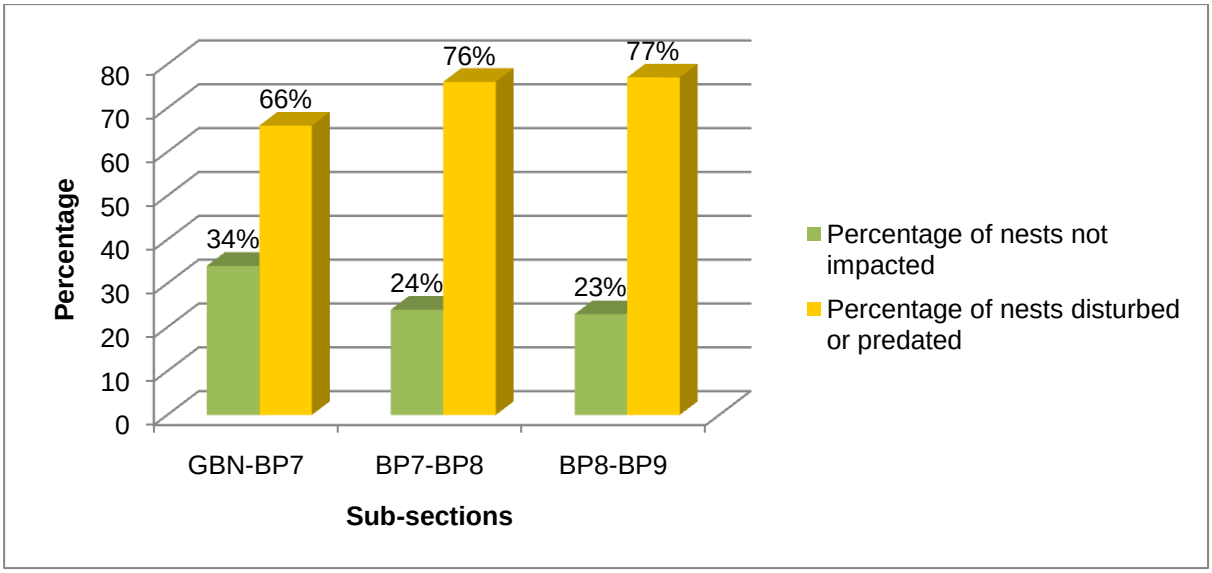

Figure 12: **Cumulative percentage of Loggerhead (*Caretta caretta*) nests disturbed, predated and not impacted by crabs per sub-section within Study Area 2010/11 (13/11/10 – 07/02/11)**

10.4.4 Nest disturbances by environmental conditions

During the monitoring season 2010/11, 4 types of environmental damages were recorded (namely erosion or suffocation of nests by the wind as well as erosion or inundation of nests by tides).

There were 2 major cyclone events during the monitoring period: Cyclone Vince (16 - 17 December 2010, 237mm of rain recorded by the Gnaraloo Weather Station, a short episode of wind and low tidal coefficient) and Cyclone Bianca (27 - 28 January 2011, 39mm of rain with strong winds, unusually high tides and wave action). The GTCP team 2010/11 missed 1 day of monitoring as a result as the survey area could not be reached due to flooding of the roads.

At least 22% of nests were observed to be impacted by environmental factors during 2010/11 (refer Figure 13 below). However, given impacts from the cyclones, it is clear that the percentage of nests impacted by environmental factors had been underestimated. Impacts from the cyclones included observations by the GTCP team 2010/11 of significant sand movement, changes in beach profile due to storm surge and tidal erosion with newly created steep high sand cliffs and a more inland position of the high tide line. The changes were very evident in the northern most sub-sections of the monitored rookery, namely BP7 – BP8 and BP8 – BP9. The impacts from Cyclone Bianca were observed to be more destructive on nests than that of Cyclone Vince, with clutches being inundated, washed to sea, and eggs and dead hatchlings at various stages of development strewn along the beach in the entire rookery (from GBN – BP9). The newly created steep sand cliffs resulted in

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subsequent turtle activity being restricted to non-nesting emergences, as the females were unable to climb the cliffs and find suitable nesting areas.

Given limited available manpower, as well as the highly dynamic beach profile due to significant impacts from the cyclones, it was not possible to keep an accurate record of all environmental impacts on nests during 2010/11.

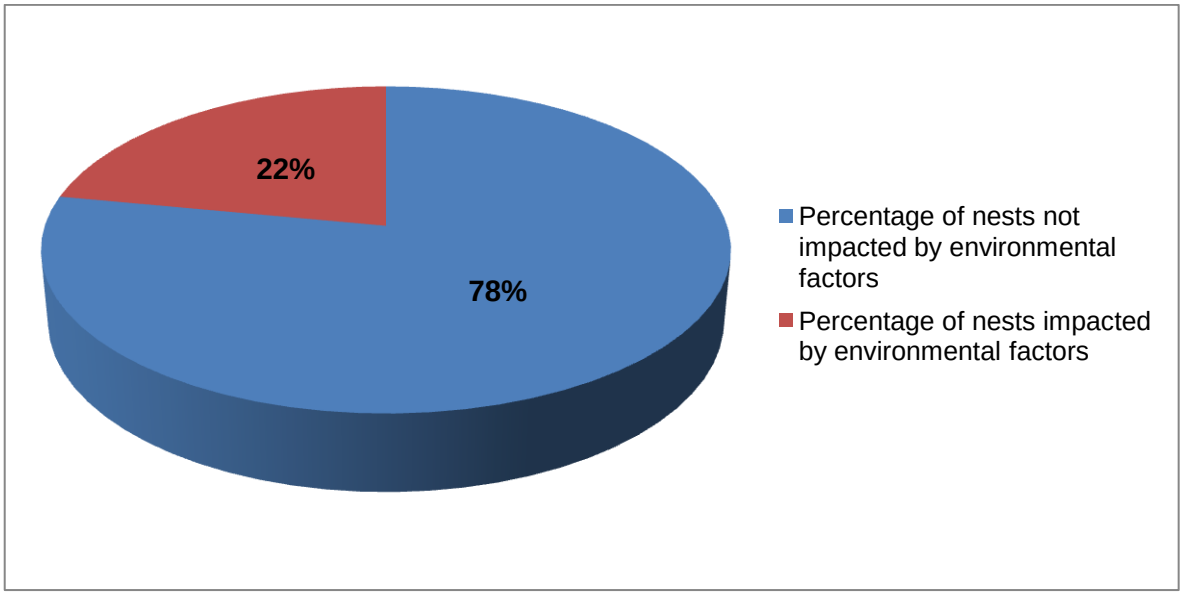

Figure 13: **Conservative percentage of turtle nests impacted by environmental conditions (winds and tides) within Study Area 2010/11 (13/11/10 – 07/02/11)**

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10.5 Discussion

10.5.1 Study Area 2010/11

The Gnaraloo Bay Rookery was again monitored during the season 2010/11. This included the area from Gnaraloo Bay North (**GBN**) to Beach Point 9 (**BP9**). The Study Area 2010/11 (6.69 km) was divided into 3 sub-sections as follows:

- **NEW** Gnaraloo Bay North to Beach Point 7 (**GBN – BP7**);
- Beach Point 7 to Beach Point 8 (**BP7 – BP8**); and
- Beach Point 8 to Beach Point 9 (**BP8 – BP9**).

Whilst GBN – BP7 is frequented by visitors and shore fishermen (especially in the first 2km of beach and around the Permanent Beach Point Marker for the historical Beach Point 6), the area BP7 – BP9 is remote with little to no human presence. Vehicle driving on beaches is not allowed at Gnaraloo.

10.5.2 Number of nests, distribution trend and nesting activity

The total number of sea turtle nests recorded over the course of the season 2010/11 resulted in 426 nests, inclusive of all species. Within the Study Area 2010/11, 799 turtle beach activities (including nests, UNAs and U tracks) were evident over the approximately 3 month monitoring period, from 13 November 2010 to 7 February 2011.

The Study Area 2010/11 was principally visited by endangered Loggerhead turtles (*Caretta caretta*), comprising approximately 94% of the turtle nests in the area. Other sea turtles that also dug nests in the area included endangered Green (*Chelonia mydas*) (2%) and critically endangered Hawksbill (*Eretmochelys imbricata*) (0.5%). It was not possible to identify the species of a total of 3% of turtle nests during the monitoring season 2010/11 mainly due to environmental effects of strong early morning winds and extreme high tides eradicating the characteristics of the tracks.

The distribution of turtle nests was non-uniform in the Study Area 2010/11 and higher nest densities were apparent in specific sub-sections. This may be due to intrinsic characteristics of the coastline and beaches such as the topography, bathymetry and currents. A previous hypothesis considering open access to the ocean as a clue to explaining highest density of turtle nests within BP8 – BP9, as opposed to sheltered beaches with adjacent fringing coral represented elsewhere in the Gnaraloo Bay Rookery, appeared to be inaccurate when reviewing a high resolution aerial photograph of the area. Areas with open access to the ocean can be seen all along the coastline, within all the monitored sub-sections (GBN – BP7, BP7 – BP8 and BP8 – BP9). As a result, a correlation

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between nest density and accessibility of the beach from the ocean is considered not to be the main indication. Nesting site selection needs to be further investigated in order to determine the factors influencing the preference for a specific nesting area.

The percentage of species composition and number of nests per species varied considerably between the monitoring seasons 2008/09, 2009/10 and 2010/11 (refer Tables 2 and 3 below). Based on the difficulty of accurately identifying a Hawksbill track compared to a Loggerhead track and the margin of error in species identification recorded by the GTCP teams 2009/10 (i.e. of the 44 out of 285 nests verified by the Night teams 2009/10, 20% had been misidentified in terms of species), it is likely that data is more accurately reflected during 2008/09 and 2010/11 than 2009/10.

	2008/09	**2009/10**	**2010/11**
Percentage Loggerhead *Caretta caretta*	90%	77%	94%
Percentage Green *Chelonia mydas*	2%	6%	2%
Percentage Hawksbill *Eretmochelys imbricata*	5%	15%	0.5%

Note: Seasonal totals are rounded and not 100% as some nests each season are unable to be identified due to track erosion by the wind and tide fluctuations.

Table 2: Percentage of species composition during 2008/09, 2009/10 and 2010/11

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	2008/09	2009/10	2010/11
Number of Loggerhead nests *Caretta caretta*	329	402	402
Number of Green nests *Chelonia mydass*	9	30	8
Number of Hawksbill nests *Eretmochelys imbricata*	20	78	2
Number of unidentified nests	10	12	14
Totals	368	522	426

Table 3: Number of nests per species during 2008/09, 2009/10 and 2010/11

Within the Study Area 2010/11, 799 tracks were recorded, with approximately 53% resulting in nests and 47% resulting in non-nesting activities (the latter comprising of UNAs and U Tracks). Consequently, approximately 1 out of 2 turtle beach activities within the Gnaraloo Bay Rookery during the nesting season 201011 resulted in a nest.

Sub-section GBN - BP7 recorded approximately the same percentage of nesting (52%) and non-nesting activities (the latter comprising of UNAs and U Tracks) (48%) within Study Area 2010/11. This result was also noticed in sub-section BP8 - BP9 (55% nests and 45% UNAs/U Tracks).

On the contrary, sub-section BP7 - BP8 presented a larger percentage of non-nesting activities (68%) (with 32% nests). Sub-section BP7 - BP8 is an area with a relatively narrow beach with rocky remains of previous coral reef and steep, high dunes. The absence of a supra-tidal area as well as the lack of access to the dune area may contribute to this higher percentage of non-nesting activities here.

10.5.3 Number of nesting females

To attempt to determine the number of nesting females in the Study Area 2010/11 formulaically, the GTCP team 2010/11 followed the previous advice provided by Dr. Mark Hamann during July 2010 [refer *Gnaraloo Day and Night Monitoring Final Report 2009/2010* (Hattingh et al., 2010)]:

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- Female Loggerhead (*Caretta caretta*) turtle population in the Study Area 2010/11 (**LTPG**) = number of nests (402) / number of clutches per season per female (4 +/- 1) (Limpus, 2008).

  LTPG = 100.2 (range 80 to 134)

- Female Green (*Chelonia mydas*) turtle population in the Study Area 2010/11 (**GTPG**) = number of nests (8) / number of clutches per season per female (6).

  GTPG = 1.3

- Female Hawksbill (*Eretmochelys imbricata*) turtle population in the Study Area 2010/11 (**HTPG**) = number of nests (2) / number of clutches per season per female (2.5).

  HTPG = 0.8

The number of nesting females per species varied considerably between the monitoring seasons 2008/09, 2009/10 and 2010/11 (refer Table 4 below). For the reasons stated above, it is likely that data is more accurately reflected during 2008/09 and 2010/11 than 2009/10.

	2008/09[3]	**2009/10**	**2010/11**
Number of Loggerhead females *Caretta caretta*	82 (range 66 - 110)	100 (range 80 - 134)	100 (range 80 - 134)
Number of Green females *Chelonia mydas*	2	5	1
Number of Hawksbill females *Eretmochelys imbricata*	8	31	1

Note: Numbers are rounded.

Table 4: Number of nesting females per species during 2008/09, 2009/10 and 2010/11

[3] **Calculation of number of nesting females per species during 2008/09:**
Female Loggerhead (*Caretta caretta*) turtle population at Gnaraloo in the Study Area 2008/09 (**LTPG**) = number of nests (329) / number of clutches per season per female (4 +/- 1) (Limpus, 2008).
LTPG = 82.25 (range 66 - 110)
Female Green (*Chelonia mydas*) turtle population at Gnaraloo in the Study Area 2008/09 (**GTPG**) = number of nests (9) / number of clutches per season per female (6).
GTPG = 1.5
Female Hawksbill (*Eretmochelys imbricata*) turtle population at Gnaraloo in the Study Area 2008/09 (**HTPG**) = number of nests (20) / number of clutches per season per female (2.5).
HTPG = 8

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The number of female Loggerhead turtles appears to have remained stable since the monitoring season 2009/10, whereas the numbers of Hawksbill and Green turtles seemed to have decreased significantly. The margin of error in species identification identified during the monitoring season 2009/10 (Loggerhead nests misidentified as Green or Hawksbill nests) may explain this occurrence.

10.5.4 Nest disturbances by introduced and native species

Foxes (*Vulpes vulpes*)

The monitoring season 2010/11 consisted of 87 sample days. No fox tracks were recorded within the Study Area 2010/11. This may be due to the efficiency of the Gnaraloo Fox Control Program (**GFCP**) undertaken as a partnership between Gnaraloo, DEC and APMS with successful intensive baiting since 2008 which may have destroyed core fox populations in the area and/or to the unusual weather associated with successive almost back-to-back cyclones observed during the nesting season 2010/11.

Crabs

A minimum of 2 species of Ghost (or Sand) crabs were observed throughout the Study Area 2010/11, namely: Golden ghost crab *(Ocypode convexa*) and Running ghost crab *(Ocypode ceratophthalma*) (refer Photo Plates).

The Golden ghost crab (*Ocypode convexa*) was predominant throughout the Study Area 2010/11 and was observed to be a predator of both sea turtle eggs and hatchlings. Running ghost crab *(Ocypode ceratophthalma*) was also witnessed to predate on sea turtle hatchlings (refer Photo Plates), but more observation is required to draw definite conclusions.

An unusual specimen of Golden ghost crab (*Ocypode convexa)* was observed with a red colouration pattern (refer Photo Plates). After seeking advice from experts concerning the specimen, including Dr. Bob Prince (DEC Perth) and Andrew Hosie and Lee Betteridge (Museum of Western Australia), as no references regarding colour variation for this species existed, it was assumed that the colour was due to either epibiotic growths or some type of infection of the carapace.

For the purpose of the Day monitoring, disturbance and predation by crabs were recorded when there was any evidence of burrowing activity into the nest (refer Glossary for definitions). The disturbance and predation of turtle nests by crabs was high within the Study Area 2010/11 (respectively 35% and 38%). A total of 310/426 nests (73%) were disturbed and/or predated by crabs during the study season 2010/11.

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10.5.5 Environmental and location impacts on nests

The unrelenting and often strong southerly winds characteristic of the Gnaraloo coastline during the annual monitoring period cause a significant degree of sand movement and drifts along coastal dunes that bury nests. This leads to the visual loss of the wooden nest identification markers and may impact on the hatching success of that nest later during the season.

Many of the beaches within the Study Area 2010/11 are relatively narrow and steep; high tides and large swells result in a high degree of erosion and sediment movement along the beach topography which impact a number of turtle nests.

Cyclone events during the monitoring period 2010/11 impacted the Gnaraloo Bay Rookery. The first cyclone, Vince, resulted in heavy rain (237mm) over a 48 hours period during mid December 2010 which flooded the Gnaraloo property and roads. However, given low strength of associated winds and a low tidal co-efficient, the impact on the beach profile and nests within the Gnaraloo Bay Rookery were not significant. The second cyclone event, Bianca, occurred during late January 2011. With only 39mm rain but strong associated winds and a high tidal co-efficient, it impacted significantly on the beach profile and eroded a large number of turtle nests within the monitored Gnaraloo Bay Rookery. Specific beach areas within the Study Area 2010/11 are more susceptible to these impacts than others and those beaches that are not protected by adjacent fringing reefs experienced the highest degree of erosion (i.e. BP 8 – BP9), and this unfortunately often coincided with the highest nesting densities.

Weather data (daily air temperature and rainfall) was recorded daily by the Gnaraloo Weather Station during the monitoring period 2010/11, and is available for future analysis and correlation with turtle nesting activity.

10.5.6 Significance of the Gnaraloo Bay Rookery

It is understood that a rookery with 300 nests per season is considered to be a significant turtle rookery (B. Thomson, Mon Repos research facility, Bundaberg, Queensland, Personal communication, 2009). The Gnaraloo Bay Rookery contained 426 recorded nests during the monitoring period 2010/11 with an approximately 7km stretch of beach and as such is considered to be a significant sea turtle rookery.

Advice received during March 2011 from DEC, Shark Bay Division (refer Reference list), stated that Dirk Hartog Island (Shark Bay) has the biggest Loggerhead rookery in Western Australia (**WA**) while

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Bungelup (Cape Range National Park) and Gnaraloo Bay probably have the highest nesting densities for Loggerheads on the mainland. Seasons like 2010/11 resulted in most of the main nesting beach at Dirk Hartog Island being unexpectedly washed away which reinforces the importance of viewing all breeding beaches together to sustain the population. Dirk Hartog is not necessarily secure as a unit by itself and active conservation at significant mainland rookeries like Gnaraloo Bay is important for the Loggerhead population as a whole.

The advice also stated that the Gnaraloo Bay turtles are recognised as part of the third largest Loggerhead turtle population in the world and is probably the best vantage point along the population's range to record the parameters of their breeding biology. This is because it is on the mainland, has accommodation facilities, and the relative density of Loggerhead nests means that enough data can be gathered to be statistically meaningful.

During March 2011, GTCP data sets were released to DEC Shark Bay researchers for input and use in estimates of Loggerhead population numbers in WA.

Written advice from James Cooke University during February 2010 (refer Reference list), stated that there are few long term data sets for sea turtles in WA, in particular for Loggerheads. While most of the Loggerhead turtle nesting sites in WA are offshore and remote, the Gnaraloo coast provides an excellent opportunity for the collection of cost effective, robust long term monitoring data.

The CSIRO, Marine and Atmospheric Research Division, Tasmania, used historical GTCP data sets for ecosystem modelling work for the Ningaloo-Exmouth region that is attempting to capture system function (from physics and biology to economics and social interactions) and give insight into sustainable development and natural resource management. The CSIRO stated during February 2010 (refer Reference list) that turtles and their survivorship is a particularly important objective for the region, but one that is also highly uncertain. Using data from other areas along the Ningaloo coast and other regions around Australia has shown that the models are very sensitive to the assumptions and parameterisation used. At present there is insufficient information from the region to completely clarify the status of this critical system component. The work in the north of the region is extremely helpful, but is spatially constrained. The size of the Gnaraloo Bay Rookery means that it is likely to make a substantial contribution to the Loggerhead turtle population. Gnaraloo's geographic location is in an area where there is no information available on the turtles and related system components. Together this makes the monitoring work in the Gnaraloo Bay Rookery a key source of information that could help reduce uncertainty about the functioning of the system and conservation management. One of the biggest drawbacks to effective provision of advice in support of sustainable development and management is the paucity of long term Australian datasets at the

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scale required by the models. Monitoring at the Gnaraloo Bay Rookery is an important ongoing source of data on a vast remote coastline.

10.5.7 Potential additional significant rookeries at Gnaraloo

An Aerial survey was again undertaken during January 2011 in order to identify and confirm any additional significant sea turtle rookeries at Gnaraloo, other than the Gnaraloo Bay Rookery presently being monitored. Results showed a significant amount of turtle activity along the Gnaraloo coastline north of the Gnaraloo Bay Rookery, as far as Gnaraloo's most northern border (called the Gnaraloo Northern Rookery). The previous Aerial survey carried out during January 2010 showed approximately the same pattern of nesting activities along the Gnaraloo coastline (refer Maps).

The Gnaraloo Northern Rookery extends over approximately 10km. During 2009/10, it contained 12 turtle activities on the day of the aerial survey. On the survey day 2010/11, a total of 15 activities were recorded in this area, with only 4 activities being recorded in the Gnaraloo Bay Rookery. Results of these aerial surveys indicate a second significant nesting site at Gnaraloo.

The Gnaraloo Northern Rookery was visited by the GTCP team 2010/11 on 12 February 2011 for purposes of recognisance (refer Photo Plates).

Because of the close proximity of the Gnaraloo Bay Rookery and the Gnaraloo Northern Rookery, it is possible that nesting females use both rookeries during the same nesting season, which would mean a current potential underestimation of the nesting female population size at Gnaraloo. However, further research needs to be conducted before any definite conclusions can be made.

The information gathered through the Aerial surveys 2009/10 and 2010/11 could result in an extension in future of the area currently being monitored (i.e. from Gnaraloo Bay to Beach Point 9). An out-camp at the Gnaraloo Northern Rookery would facilitate this and allow GTCP team members, or university researchers, easier access to breeding beaches that are a greater distance from the Gnaraloo Homestead precinct.

10.5.8 Conservation status of Gnaraloo turtles

The IUCN Red List (**IUCN, 2011**) status of 2 of the 3 sea turtle species nesting within the Gnaraloo Bay Rookery have remained unchanged since the monitoring season 2009/10. The classification of Loggerhead (*Caretta caretta*) and Green (*Chelonia mydas*) turtles are endangered, while Hawksbill (*Eretmochelys imbricata*) are critically endangered.

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According to the IUCN Red List, a taxon is endangered when it is facing a **very high risk of extinction** in the wild in the near future. Akin to this, a taxon is critically endangered when it is facing an **extremely high risk of extinction** in the wild in the near future. This is based on criteria related to observed population reduction caused by any number of factors.

As illustrated by Figure 14 below, the Study Area 2010/11 is mainly frequented by endangered sea turtles (Loggerheads and Greens). Although there were 14 unidentified nests during the monitoring period 2010/11 (due to track erosion), those turtles are likely to also be of the species known to breed in the Gnaraloo Bay Rookery.

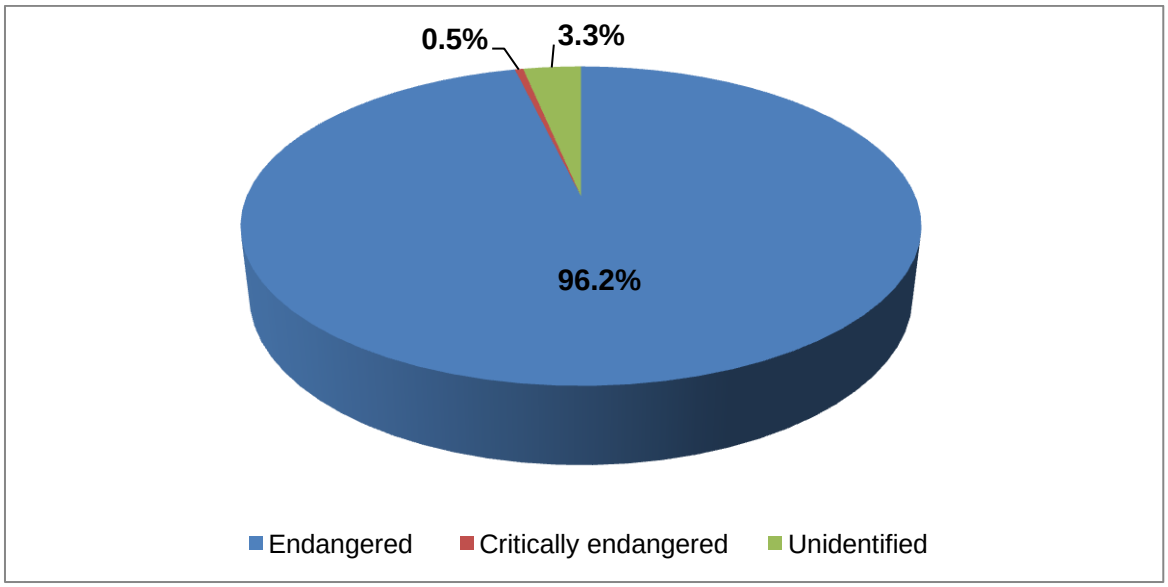

Figure 14: Percentage of endangered sea turtle species within Study Area 2010/11 (13/11/10 – 07/02/11)

10.5.9 Data integrity

Although the data collection and management protocols set out in the *GTCP Monitoring Procedure 2010/11* (Hattingh *et al.*, 2011) were strictly adhered to, a slight ambiguity in the results at times was unavoidable due to the lack of experience in track identification by the GTCP team at the beginning of the season as well as a wide variety of environmental conditions which impacted the nests and nest data collection. This included strong winds, sand drifts, beach erosion and sediment movement due to a variety of environmental factors including cyclones. For this reason, GTCP researchers 2010/11 developed a Night survey component (refer later in report) in order to check correlation

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between day results and observations at night in order to confirm correct species identification and nest activity characterization.

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10.6 Conclusions

10.6.1 Number of nests, distribution trend and nesting activity

Day monitoring activities during 2010/11 successfully collected further data on the nesting population and characteristics of sea turtles along the Gnaraloo coastline to contribute to baseline data recorded by the GTCP since 2008.

A total of 426 turtle nests, inclusive of all species, were recorded within the Gnaraloo Bay Rookery during 13 November 2010 to 7 February 2011. The dominant species observed in the rookery was Loggerhead (*Caretta caretta*) turtles (94%).

The nesting season 2010/11 peaked earlier (3 - 9 January 2011) and ended earlier (on 5 February 2011) (monitoring efforts ceased on 7 February 2011) than previous years with less total turtle nests being recorded than during 2009/10. This might be due to significant impacts from consecutive cyclones during the nesting season 2010/11.

Approximately 1 out of 2 turtle beach activities within the Gnaraloo Bay Rookery during the nesting season 201011 resulted in a nest.

GBN – BP7 and BP8 – BP9 had the greatest number of turtle nests, with 106 and 261 respectively (versus 35 nests in BP7 – BP8).

10.6.2 Number of nesting females

The number of nesting females was calculated as 100 (range 80 to 134) Loggerheads, 1 Green and 1 Hawksbill (all numbers are rounded).

10.6.3 Nest disturbance and predation

The nests within the Study Area 2010/11 faced a variety of predatory (by native species such as crabs) and environmental impacts (such as loss of nests due to erosion from tides, large swells and sand dune drifts).

No fox tracks were recorded within Study Area 2010/11 during the 87 sample days. This may be due to the efficiency of the specialized Gnaraloo Fox Control Program (**GFCP**) that has been in operation since 2008 and/or to the unusual weather observed during the season associated with a succession of cyclones.

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In order to maintain fox numbers to a minimum, it is strongly recommended that structured fox baiting events continue to be undertaken in future as soon as fox tracks are observed by GTCP researchers within the Gnaraloo Bay Rookery and to repeat the baiting events at the beginning of each month during the turtle breeding season and prior to the annual fox breeding season. This will not only protect eggs whilst incubating, but also reduce predation on emerging hatchlings later during the season.

Crabs contributed significantly to nest disturbance and predation during the nesting season 2010/11, with direct burrowing into nests. There are at least 4 species of crabs present within the Gnaraloo Bay Rookery, including Golden ghost crab *(Ocypode convexa*) and Running ghost crab *(Ocypode ceratophthalma*), and the impact by all species of crabs on turtle nests and hatchlings needs to be further investigated in order to draw any definite conclusions.

Cyclone Bianca (27 – 28 January 2011) significantly impacted beach profile and eroded a large number of turtle nests within the Gnaraloo Bay Rookery. Specific beaches within the rookery are more susceptible to this than others. Those beaches that are not protected by adjacent fringing reefs experienced the highest degree of erosion, and this unfortunately often coincided with the highest nesting densities (BP 8 – BP9).

10.6.4 Significance of Gnaraloo Bay Rookery

The Gnaraloo Bay Rookery is considered to be a significant rookery given the number of nests dug per season within a 7km area and advice from peers such as DEC, James Cook University and CSIRO.

10.6.5 Potential additional significant rookeries at Gnaraloo

There is a potential additional significant sea turtle rookery at Gnaraloo, namely the Gnaraloo Northern Rookery. It is possible that nesting females use both rookeries during the same nesting season which would mean a potential current underestimation of the size of the nesting population at Gnaraloo. The practicality of monitoring the additional area needs to be explored in future as well as the possibility of the establishment of a remote camp in this area in order to facilitate this.

10.6.6 Conservation status of Gnaraloo turtles

Loggerhead (*Caretta caretta*) turtles have remained endangered (2008 – 2011), while the classification of Hawksbill (*Eretmochelys imbricata*) turtles has been revised from vulnerable species

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(2008/09) to critically endangered species (2009 - 2011). The Green (*Chelonia mydas*) turtle status has been revised from vulnerable species (2008/09) to endangered species (2009 - 2011) (IUCN Red List 2011).

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11 NIGHT SURVEYS 2010/11

11.1 Objectives

The objectives of the night surveys were as follows:

- Determine the margin of error in species identification and determination of nest activity type through morning track monitoring and whether this was statistically significant enough to compromise overall data accuracy.
- Improve the knowledge of GTCP team members of various species tracks and the characteristics of nests and unsuccessful nesting attempts, to increase the accuracy of the day monitoring efforts.
- Irrefutably determine the species nesting within the study area, by visual identification and photographic proof (for Hawksbills only).

Refer to the section titled 'Introduction' for an overview and more detailed information of the objectives of the GTCP.

11.2 Survey area

Due to the large area of the monitored Gnaraloo Bay rookery (approximately 6.69 km of coast line), the night survey area was limited to a 1.72 km stretch of coast between BP8 - BP9. This area was selected due to high levels of turtle activity, varied nesting conditions and relative ease of access compared to other sub-sections of the rookery.

11.3 Materials and Methods

Equipment and methodology used during the night surveys 2010/11 are fully described in the *GTCP Monitoring Procedure 2010/11* (Hattingh *et al*., 2011).

Night surveys were undertaken for part periods during 19 November 2010 – 18 January 2011.

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11.4 Results

11.4.1 Species identification

During night surveys 2010/11, a total of 57 turtles were encountered in the monitored Night sub-section. Loggerhead (*Caretta caretta*) turtles were predominantly spotted with 56 individuals (98%) and only 1 Green (*Chelonia mydas*) was seen during the survey period.

Of the 57 turtles, 55 had been correctly identified by GTCP Day researchers 2010/11 in terms of species. 2 turtles were misidentified as follows:

- Tracks identified as Green turtles in the morning were accurately identified as Loggerhead turtles the previous night.

As can be seen in Figure 15, 96.5% of the results positively correlated between the night surveys and the subsequent morning monitoring work and only 3.5% negatively correlated.

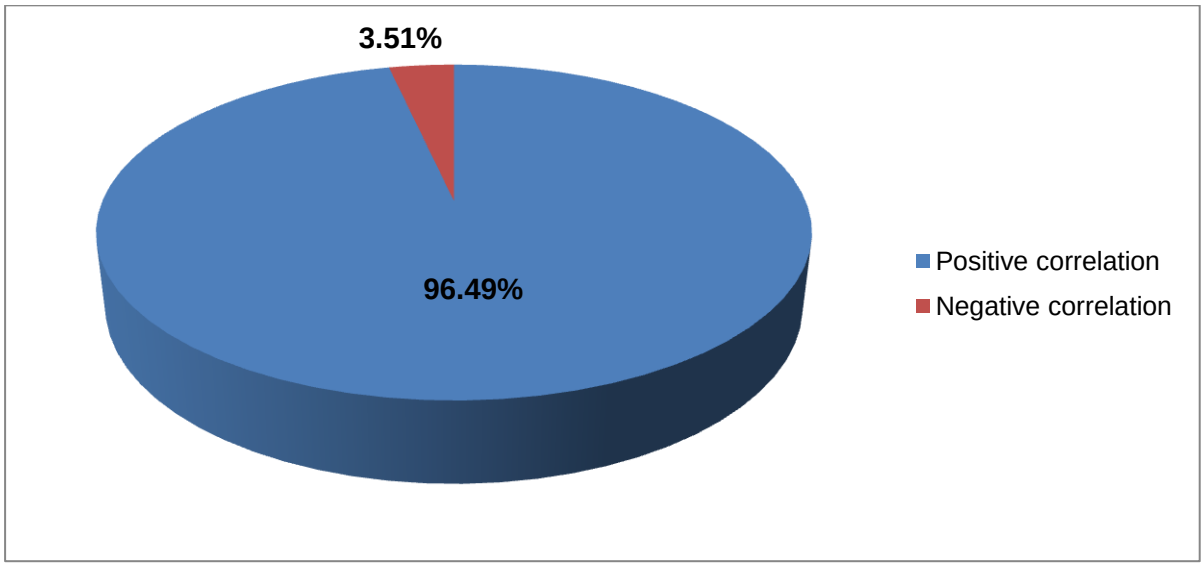

Figure 15: Correlation of species identification data in monitored Night sub-section 2010/11 (19/11/10 - 18/01/11)

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11.4.2 Nest activity type determination

Of the 57 turtles encountered within the monitored Night sub-section 2010/11, 51 activities had been correctly determined and 6 activities were incorrectly determined, as follows:

- 5 turtle activities identified as Unsuccessful Nesting Attempts (**UNAs**) in the morning were accurately identified as nests the previous night (the turtle had been seen laying eggs);
- 1 turtle activity identified as a nest in the morning was accurately identified as a UNA the previous night (the turtle left the body pit without laying eggs).

As Figure 16 demonstrates, 89% of the results positively correlated between the night surveys and the subsequent morning monitoring and 11% negatively correlated.

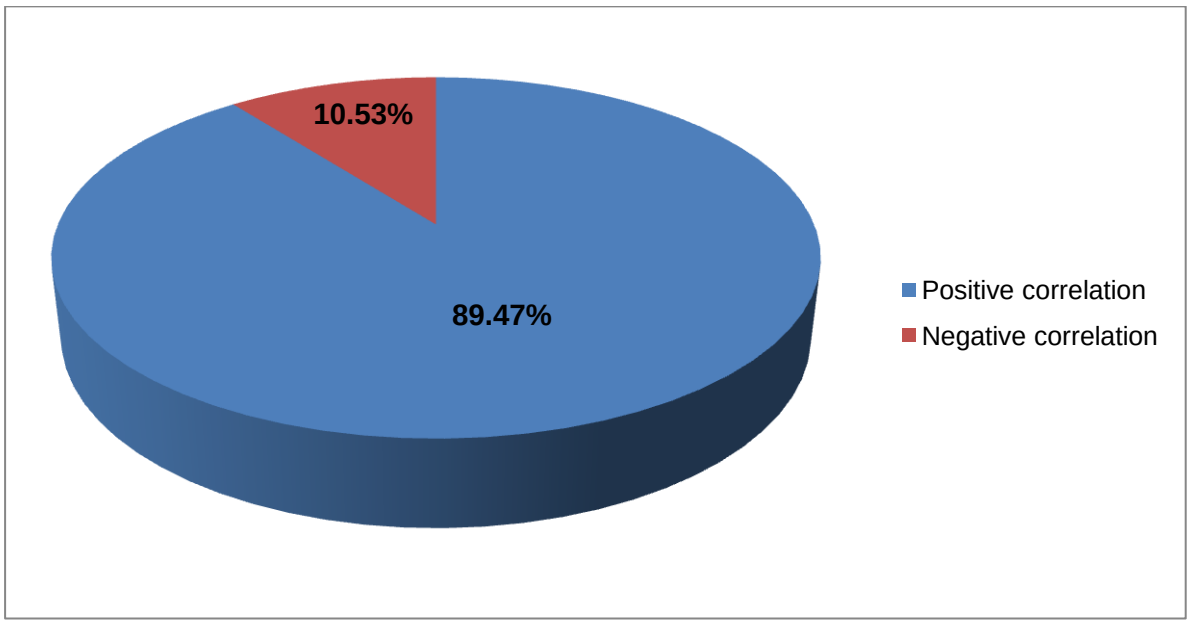

Figure 16: Correlation of nest characterisation data in monitored Night sub-section 2010/11 (19/11/10 - 18/01/11)

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11.5 Discussion

11.5.1 Species identification

Of the 57 turtles encountered within the monitored Night sub-section 2010/11 (BP8 – BP9), 55 (96.5%) had been correctly identified by Day team members in terms of species.

Turtles misidentified were identified as Green turtles during the morning track monitoring and correctly identified as Loggerhead turtles the previous night. The 2 species misidentifications occurred during the first month of monitoring when the knowledge of track characteristics of GTCP team members was still incomplete. After 1 month of frequent night surveys and daily morning monitoring, species identification reached 100% accuracy and correlation.

Besides, it appears that Loggerhead turtles tend to produce a symmetrical pattern when climbing a steep slope such as a high dune (especially visible on emerging tracks) which introduces an additional source of error that can lead to misidentification. It might explain why the 2 Loggerhead turtle tracks were identified as Green turtle tracks by the GTCP team members early in the season 2010/11.

11.5.2 Nest activity determination

Of the 57 turtles encountered within the monitored Night sub-section 2010/11, 51 (89%) turtle activities had been correctly identified.

Activities incorrectly determined were mainly UNAs (recorded in the morning) that were accurately identified as nests during the previous night survey (the turtle had been seen laying eggs). This margin of error can be explained by the lack of experience of the GTCP researchers 2010/11 in nest determination (especially at the start of the nesting season), but also by a wide variety of environmental conditions impacting the tracks as well as nest data collection. This includes strong winds, sand drifts, beach erosion and sediment movement due to high tides. Nest activity type determination for Loggerhead turtles is subject to more uncertainty than Green turtles nests. Loggerhead turtles move a small amount of sand when nesting, which produces a small and shallow body pit which is extremely well camouflaged at times. All the nest characteristics for Green turtles, as provided during training by DEC Exmouth do not apply and could not be fully used for Loggerhead turtles in the Study Area 2010/11.

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Of the incorrect activity determinations (11%), 5 out of 6 were nests that had been mistaken as Unsuccessful Nesting Attempts (**UNAs**). This may mean that nest numbers (426 nests and 216 UNAs) recorded in the Gnaraloo Bay Rookery during the season 2010/11 is conservative and with more extensive night survey checks, may have been adjusted upwards.

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11.6 Conclusions

Night surveys during 2010/11 successfully collected valuable data of the accuracy and margin of error associated with morning track monitoring (in terms of species identification and nest activity type determination) in order to establish and confirm the reliability of data collected during the nesting season.

11.6.1 Species identification

In terms of species identification, 96.5% of results positively correlated between the night surveys and morning track monitoring. These results confirm the accuracy and the integrity of 2010/11 data for species identification and show that several weeks of training in track monitoring are essential in order to become 100% efficient and reliable in terms of species identification.

11.6.2 Nest activity determination

In terms of nest activity determination, 89% of results positively correlated between the night surveys and the morning track monitoring and 11% negatively correlated. These results confirm a good accuracy in nest activity type determination, but also highlight a non-negligible source of error that has probably led to an under-estimation of the number of nests (i.e. identified as UNAs through the nesting season but not checked by night surveys) during 2010/11. It can be assumed that this kind of underestimation may also have occurred during previous monitoring seasons 2008/09 and 2009/10.

It has to be noted that even after 3 months of daily monitoring, several nest activities were still hard to determine by the GTCP researchers 2010/11 due to environmental conditions impacting the tracks as well as the nest activity. As a result, becoming 100% efficient in terms of Loggerhead nest activity determination may be hard to achieve even after many years of experience in Loggerhead nest identification. Future GTCP researchers need to consider as many clues as possible and provide the most appropriate judgment in order to reduce the margin of error in nest activity type determination.

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12 CRAB BURROW SURVEYS 2010/11

12.1 Objectives

The objectives of the crab burrow survey study were as follows:

- Investigate the density and spatial distribution of crab populations in the study area, through crab burrow surveys.
- Show the vertical distribution and horizontal zonation of crab burrows along the study area.
- Investigate and identify the different crab species present in the study area.

Refer to the section titled 'Introduction' for an overview and more detailed information of the objectives of the GTCP.

12.2 Survey area

The crab burrow survey was carried out in the Gnaraloo Bay Rookery (approximately 6.7km), located between -23.76708°/113.54584° (**GBN**) and - 23.72195° / 113.57750° (**BP9**).

12.3 Materials and methods

Due to the high density of crabs observed on the beach during morning track monitoring, as well as the recorded levels of crab predation on nests and hatchlings during the season 2009/10, a survey plan was designed and developed to determine the density and spatial distribution of crab burrows along the study area during the nesting season 2010/11.

Equipment and methodology used during crab surveys 2010/11 are fully described in the *GTCP Monitoring Procedure 2010/11* (Hattingh *et al*., 2011). Crab surveys were undertaken for part periods during 12 December 2010 – 7 February 2011.

12.4 Results

A total of 5 surveys were conducted in the Gnaraloo Bay Rookery during 2010/11, namely on:

- 12 December 2010;
- 27 December 2010;
- 11 January 2011;
- 25 January 2011; and

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- 7 February 2011.

Each survey consisted of 33 (30m^2) quadrats every 200m along the Study Area 2010/11.

12.4.1 Density and Vertical distribution of crab burrows

Crab burrows were present all along the Study Area 2010/11 from the calm, static beaches of Gnaraloo Bay to the dynamic beaches and mobile dune systems of BP9, 6.7km northwards (refer Maps).

Low crab burrow density was observed from GBN to halfway between BP7 - BP8.

The majority of crab burrows were located from halfway between BP7 – BP8 northwards to BP9, with 20 - 35 burrows per 30m^2 quadrat.

The highest density of crab burrows was observed around the Permanent Beach Point Marker at BP8, in the low dune area.

12.4.2 Horizontal zonation of crab burrows

Crab burrows were then divided according to presence within various zones on the beach, namely:

- Inter-tidal (**I**);
- Supra-tidal (**H**)[4]; and
- Dune (**D**).

Results on the location of crab burrows were as follows (refer Maps):

- 71% in the Inter-tidal zone;
- 26% in the Supra-tidal zone; and
- 3% in the Dune zone.

[4] The supra-tidal zone is abbreviated as 'H' (High tide zone) as per the definitions used by the Ningaloo Turtle Program, DEC, Exmouth District.

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12.5 Discussion

12.5.1 Density and Vertical distribution of crab burrows

The presence of crab burrows all along the Gnaraloo Bay Rookery shows that even if there are variations in the spatial distribution of crab burrows, no areas within the rookery are exclusive of crab burrowing activities. However, a clear preference for dynamic beaches, with soft sands and mobile dune systems (i.e. from halfway between BP7 – BP8 northwards to BP9) was observed.

On the contrary, a small amount of crab burrows were monitored within the calm and static beaches of Gnaraloo Bay from GBN to halfway between BP7 – BP8. This can be due to the hard and compacted sand present within this area.

Results highlight a correlation between crab burrow density and turtle nesting activity as areas presenting the highest number of crab burrows were also areas with the highest number of turtle nests (**BP8 - BP9**).

12.5.2 Horizontal zonation of crab burrows

The majority (71%) of crab burrows was observed in the Inter-tidal zone.

No source of explanation concerning this pattern of horizontal zonation could be found. As a result, only assumptions can be made in order to explain it, including:

- proximity to the water in order to hide or escape from predators;
- proximity to the water in order to keep gills moist and extract oxygen from the air;
- sand moisture in the Inter-tidal zone allowing a better and easier burrowing process; and/or
- higher presence of plants such as sea weed or micro-organisms in the Inter-tidal zone used as a source of food.

However, the presence of the majority of crab burrows in the Inter-tidal zone, as opposed to the Supra-tidal and Dune zones, is clearly not an impediment to easy access for crabs to turtle nests on the beach as the number of crab burrows within turtle nests recorded by GTCP researchers during 2010/11 ranged from 1 – 48 per nest (refer section on Day monitoring).

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12.6 Conclusions

12.6.1 Density and Vertical distribution of crab burrows

Crab burrows were present all along the Gnaraloo Bay Rookery. A pattern of vertical distribution of crab burrows was observed with a clear preference for the northern part of the rookery (i.e. from halfway between BP7 – BP8 northwards to BP9). A correlation between the distribution of crab burrows and turtle nesting activity was noted, reinforcing the hypothesis of a relationship between the crab and turtle populations.

Further research needs to be carried out to identify the species of crabs that burrow into turtle nests, assess the impact of crab burrowing activities on turtle nests (i.e. equates to no impact, disturbance or predation of egg chambers) and evaluate the size of the various crab populations that prey on turtles within the Gnaraloo Bay Rookery.

12.6.2 Horizontal zonation of crab burrows

Only general assumptions can be made considering the high density of crab burrows within the Inter-tidal zone, including protection from predators, sand moisture and food presence. However, the presence of the majority of crab burrows in the Inter-tidal zone, as opposed to the Supra-tidal and Dune zones, is not an impediment to easy access for crabs to turtle nests on the beach.

Further studies need to be developed in order to understand and explain this pattern of horizontal zonation and to provide additional information on the dynamics, behaviour and ecology of crab populations in the Gnaraloo Bay Rookery.

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13 RECOMMENDATIONS

The following section outlines recommendations for future monitoring seasons at Gnaraloo. The scope of the program in future will again be tailored to reflect available resources.

13.1 Day monitoring

13.1.1 Pre-season training 2011/12

Formal training in West Australian track monitoring protocols was provided by DEC in Exmouth at the start of the Gnaraloo season 2010/11. While the quality of training was high, the focus of track identification was on Green turtle tracks (as the Exmouth rookery predominantly receives Greens), with no Loggerhead turtle tracks being encountered during the training sessions during November 2010 (Duffy) and December 2010 (Boureau and Wall). With Gnaraloo beaches predominantly receiving Loggerhead nesting females, GTCP researchers could not confidently identify tracks or nest activity determination especially at the start of the season, which resulted in a number of data errors. It is strongly advised that training at the start of the season 2011/12 be more species-specific by providing on-beach training on Loggerhead turtle tracks, possibly onsite at Gnaraloo should resources and logistics allow this.

13.1.2 Study Area 2011/12

It is recommended that the Study Area 2011/12 maintain the sub-sections within the Gnaraloo Bay Rookery as used during the season 2010/11 for data continuity and in order to fully capture differences within the total monitored area (i.e. GBN - BP7, BP7 - BP8 and BP8 - BP9).

The historical GBN – BP6 needs to be retained as a control area, for comparison purposes with other areas in the Gnaraloo Bay Rookery with distinctive differing features such as BP8 – BP9 (in terms of beach profile, characteristics and topography). This is important for research projects such as the JCU BSc. Honours project 2010/11 that investigated factors that influence nest site selection and preferences of female turtles.

The Gnaraloo Bay Rookery (GBN – BP9) is approximately 7km long and can easily be monitored on foot (use of a 4WD quad bike is not required for track monitoring).

The Permanent Beach Point Markers consist of 5 stationary markers that remain in place from season to season. These markers are a mix of PVC pipes and star pickets, with the exception of the Gnaraloo Bay North (**GBN**) marker which comprises of the large yellow *Ningaloo Marine Park* (**NMP**)

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sanctuary pole. The GTCP team 2010/11 designed and made-up new wooden signs to more clearly demarcate the different sub-sections within the monitored rookery during future seasons. The GTCP team 2011/12 need to erect these signs during November 2011, prior to commencement of on-ground monitoring work.

13.1.3 Day monitoring program 2011/12

During the season 2010/11, formal monitoring commenced on 13 November 2010. The first turtle activity was recorded on 15 November 2010, which coincides with the first nest activity encountered during the season 2009/10. Two out of three GTCP researchers 2010/11 were onsite at the time. The monitoring season 2011/12 needs to start on 1 November 2011, with all team members present onsite by that date, if possible considering logistics and resources.

The monitoring season 2010/11 was concluded early on 7 February 2011. However, as 2010/11 may have been an unusual year, it is recommended that the monitoring period 2011/12 be based on that of the previous 2 nesting seasons at Gnaraloo (i.e. 2008/09 and 2009/10), as this seems to have encompassed the majority of nesting activities, extending from **1 November to 28 February**.

These dates are supported by the trend analysis undertaken during 2010/11, which indicated the start of the season as around 17 November and the end around 22 February annually.

While this may involve some days of monitoring with no recorded beach activities at the start and end of the nesting season, it would allow for seasonal variations in the start and end of turtle activity and would prevent the loss of data should the season start earlier or end later than previously recorded. This is especially significant given that the GTCP has only been in operation for 3 years, which does not allow for the conclusive identification of any significant trends.

13.1.4 Nest markers 2011/12

Wooden stakes were used to mark nests 1m (immediately to the east) away from the suspected egg chamber during the season 2010/11, 2009/10 and 2008/09. During the course of the monitoring season 2010/11, many of the wooden stakes were removed by tidal erosion or sand drift, resulting in inconsistent monitoring of predator and environmental damages to nests unmarked as a result.

If nests are to be closely monitored during 2011/12 for factors such as predator impact, environmental damages and hatching success, it is strongly advised to select a sample of nests and to mark only these with semi-permanent structures, which would not be affected by tides, sand drift

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and/or strong winds (e.g. 2m wooden stakes buried 1m deep in the sand). It is advised that metal structures not be used as nest markers.

A sample size of 20 – 60 nests has previously been advised by Dr. Mark Hamann. As a result, 20 – 60 wooden stakes (2m long) need to be prepared by the GTCP team 2011/12 for use during the monitoring season.

13.2 Night surveys 2011/12

Night surveys were carried out during the season 2010/11 as a complementary aspect of the morning track monitoring program, in order to assure data quality and integrity. It was designed to quantify and reduce the margin of error in species identification and nest activity determination through track monitoring, as well as to provide GTCP researchers with increased knowledge of the defining characteristics of various turtle tracks and nest activity types.

As the night surveys were highly beneficial to GTCP researchers 2010/11, particularly during the commencement and early stages of the program to verify data accuracy, it is strongly advised that night surveys again be undertaken during 2011/12. Night surveys would need to be carried out until statistical quorum is reached, i.e. 10% of total number of beach activities (including nests, UNAs and U Tracks) in seasons past.

It would be beneficial for at least 1 GTCP team member 2011/12 to have previous experience of night tracking of turtles. Researchers who lack such experience are likely to scare-off emerging and nesting turtles, due to lack of experience and awareness of the potential for negative impacts on nesting turtle behaviour. The GTCP team 2010/11 observed the Gnaraloo Loggerheads to be very susceptible to disturbance by human activity, including movements on the beach, lights and any noise. Having at least 1 GTCP researcher with previous experience in night patrols would minimise or avoid of any such impacts.

If it were possible during pre-season training, it is recommended that GTCP team members participate in night tours by the Ningaloo Turtle Program (**NTP**) in Exmouth as valuable experience would be gained in this way.

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13.3 Crab burrow survey 2011/12

The extent of nest disturbance and predation by crab species in the Gnaraloo Bay Rookery must continue to be investigated during future monitoring seasons, during both nesting and hatching periods.

During the season 2010/11, both Golden ghost crabs (*Ocypode convexa*) and Running ghost crabs (Ocypode ceratophthalma) were observed to prey on turtle hatchlings. Surveys carried out during 2010/11 provided a preliminary indication of the density and spatial distribution of crab burrows in the Gnaraloo Bay Rookery. However, burrow counts are not an accurate enough method of determining crab population density. More detailed studies are needed to determine the nature and impact of crab activity on turtle nests and hatchling survival. Mark / Recapture surveys are recommended in order to more accurately determine accurately crab population density in the Gnaraloo Bay Rookery (refer below 'Future research'). It is recommended that the crab burrow surveys carried out during 2010/11 be repeated by the GTCP team 2011/12 in order to provide data continuity.

13.4 Overall

13.4.1 Essential pre-season servicing of Gnaraloo Weather Station

The Gnaraloo weather station must be serviced prior to the commencement of the nesting season 2011/12, as the anemometer did not provide any readings during the season 2010/11. As a result, wind speed and direction were unavailable. Despite several attempts during 2010/11, GTCP researchers were unable to source or fix the problem (possibly corrosion).

13.4.2 Essential program equipment 2011/12

It is strongly advised to replace the current GPS units (x3) with more accurate models (1m accuracy). A significant margin of error associated with use of current GPS equipment during 2010/11 resulted in reduced data quality and difficulty of cross-correlation of data in the GTCP Excel Database 2010/11. For example, damaged, predated or hatched nests encountered throughout the season could often not be successfully cross-correlated with the original nest ID code, as the variability in the 2 sets of GPS readings was too large. GPS models with increased accuracy would be highly beneficial to the program, allowing the development and use of a more detailed GTCP database.

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In order to protect GPS units from Gnaraloo's highly corrosive environment, GPS protection cases for each unit should be purchased.

The purchase of upgraded UHF radios (x4) is recommended for improved safety. Such radios would allow GTCP researchers to communicate with each other within the entire study area (over 7km of beach), particularly during night surveys, allowing researchers to cover a larger monitored area and better allocate available manpower resources.

Night vision goggles would be highly desirable for night surveys. GTCP researchers 2010/11 observed the Gnaraloo Loggerheads to be very susceptible to disturbance (including human activity and lights on the beach). Use of night vision goggles would minimise potential negative impacts on emerging and nesting turtles.

Currently GTCP researchers provide their own laptops for essential program activities, including data entry, management and report writing. Whilst this will continue in future, a program laptop and/or external hard drive are highly recommended for data continuity and as an electronic library of all GTCP data, research and reference materials for use and development from year to year. This would also reduce the impact on researchers' computers which are used in all aspects of the program, including being taken out into the field to collect abiotic data from the weather station.

The list of required program equipment for the season 2011/12 should be posted on the GTCP Facebook page and displayed on onsite notice boards at Gnaraloo as soon as possible after completion of season works 2010/11, as individual persons or companies may be able to donate or gift particular items to the program.

13.4.3 Removal of fencing remnants

A nesting female was encountered trapped in remnant coastal pastoral fencing, partially buried in sand close to the Gnaraloo Bay car park, on 17 January 2011. Had GTCP researchers 2010/11 not encountered and disentangled the turtle, considering the heat, it may have had severe consequences for the individual, including dehydration, exhaustion and stress.

To prevent repeat occurrences of this in future, particularly in the absence of GTCP researchers who may otherwise see and rescue such turtles, it is strongly recommended that removal occur of fencing remnants along the vegetation line from GBN - BP6. This was attempted by GTCP researchers 2010/11 on several occasions, however, the fencing is buried at a significant depth and proved difficult to remove. It is recommended that Gnaraloo staff cut such fencing at ground level.

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13.4.4 Aerial surveys in future

Aerial surveys arranged by the GTCP during the nesting seasons 2009/10 and 2010/11 revealed similar findings, identifying the presence of a potentially significant additional turtle rookery to the northern boundary of Gnaraloo (called the Gnaraloo Northern Rookery).

As aerial surveys of the Gnaraloo coastline have revealed almost identical findings during 2010 - 2011, it is suggested that it not be repeated during the season 2011/12, with GTCP resources dedicated instead to other priority issues.

13.4.5 Monitoring of Gnaraloo Northern Rookery

Resources allowing simultaneous morning track monitoring of both the Gnaraloo Bay Rookery and the Gnaraloo Northern Rookery during 2011/12 is highly recommended. Because of the close proximity of the Gnaraloo Bay Rookery and the Gnaraloo Northern Rookery, it is possible that nesting females use both rookeries during the same nesting season, which would mean a current potential underestimation of the size of the nesting female population at Gnaraloo.

Should such additional monitoring be undertaken, it has implications for the number of GTCP researchers that would need to be appointed for 2011/12 as at least 2 further persons would be required to undertake this work.

Monitoring the Gnaraloo Northern Rookery would require the establishment and use of an out-camp by researchers (whether GTCP team members and/or university researchers) given its remoteness. Should it be monitored by GTCP team members, they would rotate on a weekly basis between the Gnaraloo Bay Rookery and the Gnaraloo Northern Rookery.

13.4.6 Community volunteer and school involvement during 2011/12

It is recommended that the community-and-schools volunteer program that was introduced during 2010/11 to allow members of the community as well as educational groups to participate with the GTCP be continued and expanded during 2011/12. A specific GTCP team member ('*GTCP Community Volunteer Co-ordinator*') was appointed to design, develop and manage the new volunteer program during 2010/11, under guidance of Gnaraloo's Environmental Advisor. It is recommended that such a team member again be appointed during 2011/12 to further develop, maintain and manage the volunteer program.

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For the season 2011/12, it is recommended that educational groups be targeted in the first instance (as opposed to individual volunteers). These groups are relatively large which maximise the outcome of educational and management efforts by the GTCP team (e.g. an instructional GTCP presentation has to be given to all volunteers prior to participation with morning patrols). Groups usually have several of its own instructors, which increases the group's overall self-sufficiency during their stay at Gnaraloo and reduces the management input required by the GTCP team. Individual volunteers generally require more management, both in terms of time, logistical arrangements and management of field work. Considering the quantity of work involved in undertaking and developing the GTCP as well as the minimal GTCP resources and manpower available onsite during the annual monitoring season, it is preferable to target large volunteer groups rather than individuals.

To maintain student interest, engagement and participation during morning patrols, given the nature of the work and field conditions, the opportunity is only made available to students who are 15 yrs or older. Group size on the beach is limited to 10 students per morning patrol in order to balance student manageability with positive group dynamics. Students participate in the daily tracks surveys under leadership of GTCP researchers which typically takes 3 - 4 hours, starting at sunrise, and involves track monitoring, species identification, counts of successful and unsuccessful nesting attempts, use of GPS equipment to record nest locations and recording observed disturbances to and predation of nests.

To maximise the chances of educational groups of encountering turtle beach activities during their field excursions to Gnaraloo, it is recommended that participation with the GTCP be arranged for January (corresponding to the peak of the annual turtle nesting season). It is recommended that groups come for 3 – 5 days, with recreational afternoon activities orientated towards providing students with an insight into the extent of marine biodiversity in the area. This may include snorkelling excursions in the *3Mile Lagoon Marine Sanctuary Zone* and *Gnaraloo Bay Marine Sanctuary Zone*.

The GTCP 2011/12 could host 2 educational groups during January (maximum of 3 groups).

The *GTCP Monitoring Procedure 2010/11 (*Hattingh *et al., 2011)* contains a list of schools which need to be contacted prior to the nesting season 2011/12 to arrange participation with the GTCP during 2011/12. It is suggested that these schools be contact by Gnaraloo's Environmental Advisor during July 2011 in order to gauge their level of interest in participation with the program as well as ensure sufficient time to plan and organise an educational field excursion to Gnaraloo during the nesting season.

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During February 2011, an hour long presentation was given to a group of 26 students and 2 teachers at Nagle Catholic College (Geraldton, Western Australia) on sea turtles, research under the GTCP and career development. The students were 16 - 17yrs old, from the faculties of Biological Sciences, Earth and Environmental Sciences and Marine Science (Certificate II in Maritime Operations) and university bound. It is recommended that the GTCP again give a presentation at a regional high school during the season 2011/12 in order to increase awareness and participation with the GTCP and its objectives and outcomes. However, given the level of interest in career development by parents of science students expressed during 2010/11, it is recommended that such presentation occur at night instead of during the day and that the parents of the students also be invited to attend.

13.4.7 GIS software and spatial analysis during 2011/12

During 2010/11, the GTCP obtained a full license of ArcGIS software at no cost under the *Esri Australia Conservation Grant Program*. During 2011/12, the GTCP need to again apply and obtain a licence, if possible, from Esri Australia to use the ArcGIS software. Should it be possible in future to buy or be gifted the ArcGIS software, it would be a significant investment in the program as it would allow unlimited seasonal use of it and reduce the amount of essential pre-season tasks which would enable Gnaraloo's Environmental Advisor and GTCP team members to focus on other program priorities.

Once a licence to use the ArcGIS software has been obtained, it is strongly recommended that an analysis be undertaken of the risk of tidal inundation of turtle nests in the Gnaraloo Bay Rookery, through using buffers of 10m, 20m and 30m to classify the alternative risk zones. This was attempted during the season 2010/11, but due to GPS inaccuracy, when the nests were mapped in the ArcGIS software, the data plots did not correlate to the actual position of nests on the beach. This was due to large variability in the GPS readings. For example, some turtle nest data plots were shown as located in the ocean. These difficulties may be overcome in future through use of more accurate GPS units to record nest data along with the current high resolution aerial photograph and new shape file of the Gnaraloo Bay coastline plotted by GTCP researchers during 2010/11 (using 150 GPS points taken at low tide).

The possibility of also producing and integrating a Digital Elevation Model (**DEM**) into the risk assessment of tidal inundation of turtle nests should be assessed in future. This may also be a potential way of mapping environmental impacts on turtle nests, such as sand accretion and erosion. Data to create a DEM should be available after the end of the JCU BSc. Honours project 2010/11

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that investigated factors that influence nest site selection and preferences of female turtles (by Ms. Taylor Bodine under the supervision of Dr. Mark Hamann).

13.4.8 Development of GTCP specific Access database in future

Day track data, night survey data and crab burrow data were entered into 3 Microsoft Excel databases during the monitoring season 2010/11. The day track database was a revised and updated version of the GTCP Day Excel Database 2009/10, while the night survey and crab burrow Excel databases were newly created.

Use of the Ningaloo Turtle Program (**NTP**) Access database was discontinued early during 2010/11 given its incompatibility with the site-specific data collected at Gnaraloo and resulting in daily double-handling (entries) of data.

Microsoft Excel is not the preferred option for recording data in a consistent, fool-proof manner. Microsoft Access is automated with drop-down lists used during data entry which ensures consistency and reduces margin of error. The GTCP team 2010/11 designed a basic Access database, however this was not completed as the creation of a database requires a certain level of prior knowledge and proficiency in Access.

It is recommended that a Microsoft Access database be specifically designed in future for the GTCP to encompass the scope of research carried out under the program. In order to be able to do this, a specific GCTP team member that is proficient in Access need to be appointed. Alternatively, the Access database may be created specifically for GTCP by an external party such as a tertiary institution, university or research body.

13.4.9 Future statistical analysis and design

Once the scope of the annual research program under the GTCP has stabilised, to ensure data quality, integrity, consistency in analysis from year to year and to accurately determine trends, it would be highly advisable to design and use a R-script for the GTCP.

R is a programming language and environment for statistical computing and graphics. It is data analysis software that allows data manipulation, calculation and graphical display[5], including:

- an effective data handling and storage facility;

[5] . R is available as free software.

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- a suite of operators for calculations on arrays, in particular matrices;
- a large, coherent, integrated collection of intermediate tools for data analysis;
- graphical facilities for data analysis and display either on-screen or on hardcopy; and
- a well-developed, simple and effective programming language which includes conditionals; loops, user-defined recursive functions and input and output facilities.

As this is a highly technical field, with a steep learning curve due to the programming language used for script redaction, specialist assistance would be required in order to create a R-script for the GTCP, which may be used to produce required seasonal statistical tests, results and graphs. In this way, potential sources of error involved in extracting data from the GTCP database would be avoided and the time needed to produce results and graphs would be reduced significantly. Advice on this needs to be sought from experts.

13.4.10Continuation of Gnaraloo Fox Control Program

The Gnaraloo Fox Control Program has been in operation since 2008 to protect Gnaraloo turtle rookeries, with structured fox baiting events by licensed specialist third party pest controller, Animal Pest Management Services (**APMS**).

No fox tracks were recorded within the Gnaraloo Bay rookery during the monitoring period 2010/11. To maintain fox numbers to a minimum and prevent a resurgence of foxes resulting in the turtle egg and hatchling predation previously evidenced at Gnaraloo, it is strongly recommended that structured fox baiting events continue to be undertaken in future as soon as fox tracks are observed by GTCP researchers within the Gnaraloo Bay Rookery and to repeat the baiting events at the beginning of each month during the turtle breeding season (November – April) and prior to the annual fox breeding season (May). This will not only protect eggs whilst incubating, but also reduce predation on emerging hatchlings later during the season.

13.4.11Recruitment of GTCP team 2011/12

Recruitment and appointment of GTCP team members in future will be carried out in a similar fashion to that of previous seasons.

It is recommended, as a minimum and as occurred during 2010/11, that the structure of the GTCP team 2011/12 again be that of *Team Leader*, *Community Volunteer Co-ordinator* and *GIS Cartographer*.

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The number of GTCP team members recruited for future seasons will depend on the scope of research for that season. Previous experience with sea turtles and monitoring projects is highly desirable and should be sought out when seeking future team members. As a minimum, GTCP team members must be proficient in Microsoft Word and Excel. In order to be able to undertake spatial analysis and mapping of data, 1 GTCP team member must have knowledge and previous experience in use of GIS software. Without prior knowledge and experience in GIS operation and data management, it would be difficult to navigate in order to produce essential maps of the season's findings. Should the decision be made in future to develop a new GTCP specific Microsoft Access database (refer above), unless the Access database is created by an external party (e.g. a tertiary institution, university or research body), 1 GTCP team member during that season need to possesses requisite skills for creating and developing such a database.

To confirm data accuracy and integrity, analyse seasonal data sets and determine trends (unless specialist help with this is sought, refer above), it would be highly desirable in future to appoint a GTCP team member with a background in statistics.

Should night surveys be repeated during 2011/12, it is recommended that 4 GTCP team members be appointed for the duration of the monitoring period. On a daily basis, this would translate as 1 GTCP team member assigned to morning track monitoring, 2 GTCP team members assigned to night surveys (for reasons of safety, night patrols must be undertaken in teams of 2) and 1 GTCP team member dealing with the daily responsibilities and management associated with the GTCP community-and-schools volunteer program.

If both night surveys and monitoring of the Gnaraloo Northern rookery were to take place during 2011/12, various options exist in terms of required resources. For example, 2 additional science graduates may be recruited, bringing the total number of GTCP team required for the season to 6 persons.

13.4.12Pre-season arrival 2011/12

It is essential that all GTCP team members arrive onsite at least 1 week prior to the commencement of formal monitoring activities to allow sufficient time for training and program set-up, including time in the offsite office of Gnaraloo's Environmental Advisor.

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13.4.13Vehicle access to the Gnaraloo Bay Rookery

Driving is not allowed on beaches (to protect breeding habitat of coastal species) or within dune systems (to protect stabilizing vegetation and habitat) at Gnaraloo with vehicles, bikes or quad bikes. GTCP researchers 2010/11 used both the **Gnaraloo Bay car park** and **BP8 pastoral car park** during the monitoring season. The Gnaraloo Bay car park was predominantly used if only 1 GTCP researcher patrolled the rookery during the day, or with small GTCP volunteer groups in the morning, as it provides easy access to the beach. The BP8 pastoral car park area was used when large GTCP volunteer groups participated with the program, as well as for night surveys which are always undertaken by at least 2 GTCP researchers.

When accessing the sub-sections BP7 – BP9, the rule of thumb with vehicles is to stay off any 'knobbly bits'!

For environmental, archaeological and paleontological heritage protection, it is **imperative** that the correct track and car park area be used when accessing sub-sections BP7 – BP9. Driving or parking indiscriminately within the area tramples vegetation (leading to erosion and blow-outs of the highly mobile dune system), destroys archaeological and paleontological heritage remnants found in the area (whether known or still to be excavated) and disturbs the sands and sediments surrounding the bone and shell fragments that are used by climate change researchers for dating purposes[6]. While the BP8 pastoral car park is adequate, the pastoral track to it is not always clearly delineated due to sand drifts, which caused confusion on occasion during 2010/11, in particular to external university turtle researchers, and resulted in vehicles being driven and parked incorrectly. It is advised to continue using the existing track to the BP8 pastoral car park whilst increasing its visibility by putting reflective stakes on either side. This would eliminate any confusion concerning access and minimise impacts by vehicles. The actual parking area next to the well at the BP8 pastoral car park needs to be delineated to improve clarity and avoid impacts by vehicles on vegetation in the surrounding arid environment as well as on possible buried archaeological and paleontological heritage materials.

For the same reasons, when collecting data from the Gnaraloo Weather Station just before BP7, it is **imperative** that GTCP researchers and external university researchers park in the correct location: simply leave the vehicle on the pastoral track used to drive-in to the location and walk to the weather station to collect data (rather than turning the vehicle off the pastoral track, driving up and parking at the weather station).

[6] Refer to 'Death of the Mega beasts', DVD, Franco Di Chiera, 2009.

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13.4.14Tasks at start of season 2011/12

First and foremost when arriving onsite and **prior to** commencement of monitoring, the GTCP team 2011/12 needs to correctly set up and install the Gnaraloo Weather Station in the field: refer *GTCP Monitoring Procedure 2010/11 (*Hattingh *et al*., 2011). When doing so, it is imperative that the GTCP team 2011/12 consider and determine the required weather data set to be recorded for the duration of the monitoring period (including at least daily temperature, humidity, wind speed and rainfall), program and test the Gnaraloo Weather Station accordingly. This issue was not successfully undertaken or resolved during previous seasons.

The GTCP team 2011/12 need to locate and erect the new wooden signs at the 5 Permanent Beach Point Markers to more clearly demarcate the different sub-sections within the Gnaraloo Bay Rookery, prior to commencement of on-ground monitoring work (refer section 'Study Area 2011/12'). The GTCP team 2011/12 also need to prepare 20 – 60 wooden stakes (2m long) for use during the monitoring season (refer section 'Nest markers 2011/12'). The GTCP team 2011/12 also need to put reflective stakes on either side of the existing track to the BP8 pastoral car park (refer section 'Vehicle access to the Gnaraloo Bay Rookery').

The GTCP team 2011/12 needs to consider and review all materials on the program flash-drive called 'Turtle Key'. The team also needs to prepare the electronic template of the seasonal report 2011/12 by:

- Base the template on that of the report 2010/11;
- Maintain the general layout and format, but delete all body text;
- Create all Headings and Sub-headings afresh and fix formatting issues with same from previous years (discuss required GTCP format styles with Gnaraloo's Environmental Advisor);
- Create the Table of Content and Table of Illustration afresh, ensure linkages with the entire document and fix issues with same from previous years (discuss with Gnaraloo's Environmental Advisor).

The GTCP team 2010/11 commenced re-designing and improving the GTCP web-page (design and text) on Gnaraloo's website (www.gnaraloo.com) (the drafts are available from Gnaraloo's Environmental Advisor). The GTCP team 2011/12 need to continue and complete such update, in discussion with Gnaraloo's Environmental Advisor and the Gnaraloo leaseholder.

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Under guidance of the GTCP Team Leader 2011/12, the GTCP team needs to consider this report and discuss recommended actions items with Gnaraloo's Environmental Advisor in order to plan and action implementation.

13.4.15Recommended future research

Recommended future research includes:

Conversion of GTCP into a university or tertiary qualification

In discussion with universities and/or tertiary education institutions, it should be considered whether the GTCP may in future be developed into a possible scientific qualification. Given the significant scope of research undertaken seasonally at Gnaraloo, a large number of competencies may be demonstrated by GTCP team members and evaluated by universities for possible award of a qualification (i.e. field work, creation and use of databases, data management and analysis, GIS cartography and redaction of the seasonal report with finding and recommendations for future).

It should be considered to publish scientific papers on GTCP data, results and findings since 2008 and/or to present same at relevant conferences, such as the International Sea Turtle Symposium.

Cross-correlation between weather data and GTCP data

It is recommended for future GTCP teams start cross-correlating the seasonal weather data collected by the Gnaraloo Weather Station with the morning track monitoring results. This may also be carried out as a research project by external university researchers, given the complexity of the work involved.

Environmental impacts: Sand accretion and erosion & Tidal inundation

Damages caused to turtle nests by environmental factors (such as wind, sand drift, tides and erosion) may be monitored by selecting, marking and monitoring (from start to finish) a sample of the total number of clutches laid during a season. Nests would need to be carefully selected in order to include the entire range of available nesting habitat conditions across the Gnaraloo Bay Rookery, including beach profile and characteristics, variations in vertical zonation, distance from the high tide mark and exposure to wind, sand drift and tides. This was only monitored on a sporadic basis during the season 2010/11, as it proved difficult to monitor the totality of nests on a regular basis given the available GTCP manpower and resources, which resulted in incomplete data.

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The evolutionary relationship between turtle and crab populations in the Gnaraloo Bay Rookery

Preliminary research concerning the relationship between crab and turtle populations in the Gnaraloo Bay Rookery was carried out during the season 2010/11. The results obtained indicated the need to research this subject in more depth. It is recommended to in future repeat the crab burrow surveys carried out during 2010/11 and also to carry out additional research to complement this work.

Suggested methods of research include Mark / Recapture surveys which would allow for more accurate determination of crab populations and crab densities along the study area, as well as the extent of individual's home range. Mark / Recapture is a method commonly used to estimate population size. This method is most valuable when a researcher is not able to detect all individuals present within a population of interest every time the researcher visits the study area. Typically a researcher would visit a study area and capture a group of live individuals. Each of these individuals is marked with a unique identifier (e.g. paint, a numbered tag or band) and then released back unharmed into the environment. Sufficient time is allowed to pass for the marked individuals to redistribute themselves among the unmarked population. The researcher returns later and captures another sample of individuals. Some of the individuals in this second sample will have been marked during the initial visit and are known as re-captures. Other animals captured during the second visit will not have been captured during the first visit to the study area. These unmarked animals are usually given a tag or band during the second visit and then released. Population size can be estimated from as few as 2 visits to the study area. Commonly more than 2 visits are made, particularly if estimates of survival or movement are required. Regardless of the total number of visits, the researcher simply records the date of capture of each individual. The 'capture history' generated as a result is analyzed mathematically to estimate population size or movement.

Mark / Recapture surveys may be carried out by GTCP teams, depending on available resources, or by university researchers.

To investigate the effect of crab disturbance and predation on turtle clutches and hatchlings, it is necessary to carry out nest excavations on a selected sample of clutches post hatching, in order to evaluate the rate of embryo mortality caused by crab activity (disturbance and predation) as well as the effect of crab burrows on micro-habitat conditions in nests (increased exposure of eggs to air, light and organisms such as microbes, ants, flies, crabs, goannas and foxes). Due to the invasive nature of this research, a conservative approach must be adapted and excavations carried out only after any chance of nest emergence. Permits must be obtained from relevant authorities. This work

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may be carried out by GTCP teams (given appropriate training in Western Australia protocols for nest excavations and depending on available resources) or by university researchers. Nest excavations would also provide critical information in relation to hatching success rates across the Gnaraloo Bay Rookery.

Possible turtle foraging or resting sites at Gnaraloo

Consistent reports during 2010 from Gnaraloo guests and visitors of turtle sightings (often Greens) in Gnaraloo waters suggest that Gnaraloo may not only be a seasonal breeding area for Loggerhead turtles, but possibly also a foraging or resting site for other turtle species, during different or overlapping parts of the year. Long term guests at 3Mile Camp believe that there are resident turtles in the immediate area, including at the Tombstones location. This needs to be investigated, including the species and number of any such turtles.

It is suggested that year round in-water surveys be conducted in future at Gnaraloo to investigate the following questions:

- Whether Gnaraloo waters are being frequented by turtles outside of the current breeding season (November to April), including when this occurs;
- Which turtle species are present (both close to the shore and further at sea);
- Whether Gnaraloo is used by turtle species as a foraging area or resting area, including the age profile of such turtles.

Considering the limited resources of the GTCP, as such research would extend past the annual Loggerhead nesting season, require the use of a boat and diving equipment, be time consuming requiring a number of surveys during different times of the year, it would need to be carried out by a university or external research body.

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14. GLOSSARY

BP6	The historical Beach Point 6 permanent marker, being the vertical white PVC pipe at the 6Mile public parking area (-23.76436°; 113.55854°).
BP7	The Beach Point 7 permanent marker, being the vertical white PVC pipe affixed atop a fore dune (-23.75001° / 113.56871°), after the Gnaraloo Weather Station .
BP8	The Beach Point 8 permanent marker, being a vertical white PVC pipe affixed atop a fore dune (-23.73631° / 113.57448°).
BP9	The Beach Point 9 permanent marker, being a vertical metal star picket on the primary dunes (-23.72195° / 113.57750°) (delineates the northernmost boundary of the Study Area 2010/11).
CCG	Cape Conservation Group, Exmouth.
Clutch	All of the eggs deposited in a single nest.
Crab burrow	Near vertical hole with an opening. The excavated sand is carried away from the burrow mouth and dispersed.
DEC	Department of Environment and Conservation, Western Australia.
DEM	Digital Elevation Model
Egg chamber	Location in which eggs are deposited; a deep hole dug into the primary body pit using the turtle's back flippers.

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Emerging track	The track made by a female as it comes from the sea to the land.
Fox **presence**	Evidence of fox tracks and/or visual of an individual fox.
GIS	Geographic Information System.
GBN	The GBN permanent marker, being the vertical yellow *Gnaraloo Bay North Marine Sanctuary Zone* marker (-23.76708° / 113.54584°) (delineates the southernmost boundary of the Study Area 2010/11).
GFCP	Gnaraloo Fox Control Program
GTCP	Gnaraloo Turtle Conservation Program.
GTPG	Female Green (*Chelonia mydas*) turtle population at Gnaraloo in the Gnaraloo Bay Rookery.
Hatchling	A newly hatched turtle.
Hatchling **predation**	Actual sighting of a predator consuming a hatchling.
HTPG	Female Hawksbill (*Eretmochelys imbricata*) turtle population at Gnaraloo in the Gnaraloo Bay Rookery.
IOSEA	Indian Ocean – South Easth Asian (IOSEA Marine Turtle Memorandum of Understanding is an inter-governmental agreement that aims to protect, replenish and recover sea turtles and their habitats in the Indian Ocean and South-East Asian region, working in partnership with other relevant organisations, www.ioseaturtles.org).

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LTPG	Female Loggerhead (*Caretta caretta*) turtle population at Gnaraloo in the Gnaraloo Bay Rookery.
Monitoring season	The entire time period during which GTCP team members monitor sea turtle nesting activities at Gnaraloo.
Nest **disturbance** by crabs	Sightings of a crab burrow(s) into a nest, with or without turtle eggshell fragments, whole turtle eggs or yolky turtle eggshells present at the surface.
Nest **disturbance** by environmental conditions	Inundation, erosion and/or suffocation of nests by tides, storm surges or shifting dunes.
Nest **disturbance** by foxes	Sightings of fox digging(s) into a turtle nest, with or without turtle eggshell fragments, whole turtle eggs or yolky turtle eggshells present at the surface.
Nest **predation** by crabs	Sightings of a crab burrow(s) into a nest **with** evidence of mortality (for example, turtle eggshell fragments, whole turtle eggs or yolky turtle eggshells visible within the crab burrows, or an exposed egg chamber) or observation of a crab actively taking a hatchling.
Nest **predation** by foxes	Sightings of fox digging(s) into a turtle nest **with** evidence of mortality (e.g. turtle eggshell fragments, whole turtle eggs or yolky turtle eggshells present at the surface or an exposed egg chamber) or observation of a fox actively taking a hatchling.
Nest success	A clutch that hatches and emerges, with neonates (newly hatched and/or emerged turtle) present at the surface.

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Night survey sub-section 2010/11	Area monitored at night for part periods during 2010/11: from the Beach Point 8 (**BP8**) marker to Beach Point 9 (**BP9**) marker.
NTP	Ningaloo Turtle Program, Exmouth.
RAM	Random Access Memory
Returning track	The track made by a female as it returns from the land to the sea.
Revised Day Study Area 2009/10	Area monitored daily: from Gnaraloo Bay North (**GBN**) to Beach Point 9 (**BP9**).
Rookery	A breeding area for a large number of animals.
Study Area 2008/09	Area monitored daily: from Gnaraloo Bay North (**GBN**) to Beach Point 10 (**BP10**).
Study Area 2010/11	Area monitored daily: from Gnaraloo Bay North (**GBN**) to Beach Point 9 (**BP9**).
Successful nesting attempt or Nest	Turtle beach activity that results in a clutch being deposited.
SWOT	State of the World's Sea Turtles (SWOT works directly with field-based sea turtle researchers across the globe, compiling the most current data available in order to provide an up-to-date global picture of sea turtle status, www.seaturtlestatus.org).
Turtle beach activity	All activities (turtle tracks) observed on the beach, including nests, unsuccessful nesting attempts (**UNAs**) and U Tracks.
Unsuccessful Nesting Attempt or UNA	The emergence of a female from the sea that does not result in the depositing of eggs. For example, a turtle is witnessed either clearing a

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	body pit or digging an egg chamber, but subsequently abandons the nesting attempt and returns to sea without depositing eggs. Peer review comment during 2009/10 stated that the term 'false crawl' is not used in Australia as a female will try to lay a clutch each time she comes ashore. At times, conditions do not favour her and she returns to sea without depositing eggs. The advice stated that the terms 'successful nest attempt' and 'unsuccessful nest attempt' are used in Australia.
U Track	The female is said to have carried out a U Track when no attempt of body pitting has been witnessed and the tracks on the beach simply appears as a 'U'.

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ATTACHMENTS

PHOTO PLATES 2010/11

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MAPS 2010/11

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GTCP SCHOOL FLYER 2010/11

Gnaraloo is a working pastoral station and wilderness tourism location adjacent to the *Ningaloo Marine Park* in a National Heritage listed and future World Heritage listed area. Gnaraloo is **Australia's 3rd largest nesting site for endangered Loggerhead (*Caretta caretta*) turtles** and also receives large numbers of endangered Green (*Chelonia mydas*) and critically endangered Hawksbill (*Eretmochelys imbricate*) turtles. The *Gnaraloo Turtle Conservation Program* (**GTCP**) was established in 2008 to undertake a range of monitoring and scientific activities during the annual breeding season. This year, it is offering students the opportunity to participate in research survey work!

What will I do?

As all the turtle species that breed on the Gnaraloo beaches are endangered, the research that is undertaken is of **international significance. Your help makes a difference!** You will assist our researchers as they carry out track monitoring, species identification, counts of successful and unsuccessful nesting attempts and identification of disturbances to or predation of nests.

But it's not all work and you'll have plenty of time to discover the pristine surroundings, with activities like snorkeling, swimming and beach fun. You will learn about sea turtle ecology, conservation status and threats from the Gnaraloo research team. They will explain their work, its ecological significance and research undertaken so far. You will also discuss how to contribute to marine and turtle conservation in your everyday life!

Highlights

Collaborate with scientific researchers on track monitoring surveys.

Build a BBQ and roast marshmallows 'under the sky of a thousand stars'.

Snorkel the Ningaloo coral reef, in lagoons renowned for their marine biodiversity

Monitoring work

Turtle tracking is not an easy job! You'll be getting up at 4am to be ready for the beach survey at 6am! You will assist our research team as they monitor tracks along the beach, recording information such as the number and spatial distribution of successful nests, unsuccessful nesting attempts and evidence of nest disturbance and predation. This involves walks (up to 10km) and can take up to 5 hours, depending on the number of nests encountered. Nesting turtles are sometimes observed during this time.

Arrangements

You will be stay at the Gnaraloo Homestead precinct in a 12 roomed building called the '*Fishing Lodge*' with communal kitchens and ablutions.

You need to bring your own food and cook your own meals. Consult with each other and bring enough ingredients to prepare communal meals in the evenings!

Other essential things to bring include long sleeved shirts and trousers, enclosed shoes, a hat, sunscreen, sunglasses, a snorkel and mask and a sleeping bag and torch (there is no power atGnaraloo between 11pm and 7am).

Be aware that you will be staying in a remote environment, in basic living conditions and doing work that is physically challenging. Be prepared to have the time of your life!

For more information, please contact Marie Duffy, *Gnaraloo's Turtle Volunteer Coordinator*, on email at marieduff@gmail.com or (08) 9942 5927

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GNARALOO WEATHER STATION DATA 2010/11

LEGEND

At the bottom of each report, the following monthly information is summarised:

Max >= 32.0:	The number of days on which the daily high temperature was 32°C or above.
Max Rain: ON [Date]	The maximum daily rainfall during the month.
Days of Rain: (>0.2 mm), (> 2mm), (> 20mm),	The number of days on which rainfall exceeded 0.2mm, 2mm, or 20mm is displayed

No wind data was recorded during 2010/11 due to issues experienced with the anemometer.

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MONTHLY CLIMATOLOGICAL SUMMARY FOR 8 – 31 DECEMBER 2010

Day	Temperature (°C)					Heat / Cool Degree Days		Rain (mm)	Wind (KPH)			
	Mean	High	Time	Low	Time	Heat	Cool		Average Speed	High	Time	Dominant Direction
8	24.3	31.1	1:00p	19.3	6:00a	0	5.9	0	---	---	---	---
9	27	38.1	2:00p	20.2	6:00a	0	8.7	0	---	---	---	---
10	31.7	43.4	3:00p	23.6	2:00a	0	13.3	0	---	---	---	---
11	27.9	35.1	9:00a	25.2 1	2:00m	0	9.6	0	---	---	---	---
12	25.2	27.3	2:00p	22.8 1	2:00m	0	6.9	0	---	---	---	---
13	22.5	27.3	9:00a	20.5	6:00a	0	1.6	0	---	---	---	---
14	29.6	39.1	2:00p	22.3	7:00a	0	8.4	0	---	---	---	---
15	26.7	32.2	10:00a	23.3 1	1:00p	0	8.4	5.6	---	---	---	---

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16	22.4	25.7	12:00m	21.6	8:00a	0	4.1	154.2	---	---	---	---
17	25.7	29	2:00p	23.0 1	0:00p	0	7.3	81.3	---	---	---	---
18	26.2	28.1	4:00p	23.7	1:00a	0	7.9	1.3	---	---	---	---
19	25.9	27.4	2:00p	25.1 1	2:00m	0	7.6	0	---	---	---	---
20	25.7	27.1	12:00p	23.8	2:00a	0	7.3	0.3	---	---	---	---
21	25.5	27.3	2:00p	23.4 1	2:00m	0	7.2	0	---	---	---	---
22	24.7	26.8	3:00p	20.8	3:00a	0	6.3	0	---	---	---	---
23	25.8	29	2:00p	22.6	5:00a	0	7.4	0	---	---	---	---
24	27.9	33.6	10:00a	24.1	1:00a	0	9.6	0	---	---	---	---
25	30.9	41.7	12:00p	25.8	3:00a	0	12.6	0	---	---	---	---
26	29.7	36.8	9:00a	26.4 1	2:00m	0	11.4	0	---	---	---	---

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27	27.4	29.1	1:00p	25.3	5:00a	0	9.1	0.3	---	---	---	---
28	29.3	38.5	12:00p	25.4	5:00a	0	11	0	---	---	---	---
29	27.1	34.2	1:00p	23.6	6:00a	0	8.8	0	---	---	---	---
30	27.1	33.8	11:00a	22.8	5:00a	0	8.7	0	---	---	---	---
31	27.8	33.4	11:00a	24.4	5:00a	0	9.4	0	---	---	---	---

Max >= 32.0 : 12

Max Rain: 154.2 on 16/01/11

Days of Rain : 6 (> 0.2mm), 3 (> 2mm), 2 (> 20mm)

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MONTHLY CLIMATOLOGICAL SUMMARY FOR 1 – 31 JANUARY 2011

Day	Temperature (°C)					Heat / Cool Degree Days		Rain (mm)	Wind (KPH)			
	Mean	High	Time	Low	Time	Heat	Cool		Average Speed	High	Time	Dominant Direction
1	29.2	39.6	12:00p	25.1	5:00a	0	10.8	0	---	---	---	---
2	28.4	34.3	11:00a	25.1	5:00p	0	10.1	45.7	---	---	---	---
3	27.9	31.4	2:00p	25.5	7:00a	0	9.6	0.8	---	---	---	---
4	28.2	30.2	1:00p	25.8	1:00a	0	9.8	0	---	---	---	---
5	28.5	30.1	11:00a	26.8	4:00a	0	9.3	0	---	---	---	---
6	---	---	---	---	---	0	0	0	---	---	---	---
7	28.7	29.9	8:00a	27.1	12:00 m	0	6.1	0	---	---	---	---

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8	28.8	35.3	1:00p	25.6	6:00a	0	10.5	0	---	---	---	---
9	30.2	35.9	12:00p	25.9	6:00a	0	11.9	0	---	---	---	---
10	30.6	34.5	10:00a	26.9	6:00a	0	12.2	0	---	---	---	---
11	32.8	40.2	1:00p	26.8	7:00a	0	14.4	0	---	---	---	---
12	30.7	38.7	11:00a	26.2	3:00a	0	12.4	0	---	---	---	---
13	28.6	33.4	1:00p	25.2	12:00 m	0	10.2	0	---	---	---	---
14	27.6	33.3	3:00p	23.5	6:00a	0	9.3	0	---	---	---	---
15	28.2	36.7	4:00p	22.4	6:00a	0	9.8	0	---	---	---	---
16	30.1	37.5	3:00p	25.1	5:00a	0	11.7	5.1	---	---	---	---
17	29.4	33.3	10:00a	25.7	5:00a	0	11.1	0	---	---	---	---
18	28.2	29.9	4:00p	26.3	7:00a	0	9.9	0	---	---	---	---

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19	27.7	29.8	10:00a	25.6	12:00 m	0	9.4	0	---	---	---	---
20	28.6	33.7	12:00p	25.1	3:00a	0	10.2	0	---	---	---	---
21	27.6	30.7	10:00a	24.3	11:00p	0	9.3	7.1	---	---	---	---
22	27.6	30.2	7:00p	24.6	1:00a	0	9.3	0.5	---	---	---	---
23	28.6	31	2:00p	26.2	5:00a	0	10.2	0	---	---	---	---
24	28.2	30.9	9:00a	25.4	12:00 m	0	9.9	0	---	---	---	---
25	26.1	32	6:00p	23.6	7:00a	0	4.8	0	---	---	---	---
26	27.6	33.7	12:00p	23.9	7:00a	0	9.3	0	---	---	---	---
27	29.3	36.3	5:00p	24.6	7:00a	0	10.9	7.6	---	---	---	---
28	28.1	29.9	11:00a	26.1	7:00a	0	9.7	8.2	---	---	---	---

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29	28.1	29.3	3:00p	26.3	7:00a	0	9.7	0	---	---	---	---
30	27.8	29.8	4:00p	25.6	12:00 m	0	9.4	0	---	---	---	---
31	27.9	34.5	2:00p	24.8	4:00a	0	9.6	0	---	---	---	---

Max >= 32.0 : 17

Max Rain: 45.72 on 02/01/11

Days of Rain : 7 (> 0.2mm), 5 (> 2mm), 1 (> 20mm)

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MONTHLY CLIMATOLOGICAL SUMMARY FOR 1 – 7 FEBRUARY 2011

Day	Temperature (°c)					Heat / Cool Degree Days		Rain (mm)	Wind (KPH)			
	Mean	High	Time	Low	Time	Heat	Cool		Average Speed	High	Time	Dominant Direction
1	27.4	31.2	12:00p	24.9	7:00a	0	9.1	0	---	---	---	---
2	26.4	29.2	11:00a	23.9	7:00a	0	8.1	0	---	---	---	---
3	26.1	28.9	3:00p	23.3	7:00a	0	7.8	0	---	---	---	---
4	26.7	29.9	4:00p	23.7	5:00a	0	8.4	0	---	---	---	---
5	27.4	33.1	12:00p	24	7:00a	0	9.1	0	---	---	---	---
6	27.6	31.4	1:00p	24.4	10:00p	0	9.3	19	---	---	---	---

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7	**28.5**	**32.6**	**6:00p**	**25**	**7:00a**	**0**	**10.2**	**0.2**	---	---	---	---

Max >= 32.0 : 2

Max Rain: 19.0 on 06/02/11

Days of Rain : 2 (> 0.2mm), 1 (> 2mm), 0 (> 20mm)

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