Eco Beach Sea Turtle Monitoring Program

Report of 2011 nesting activity for the flatback turtle *(Natator depressus)* at Eco Beach, Western Australia

Wild Futures

2012

Note by Biosphere Expeditions: Normally Biosphere Expeditions publishes its own, dedicated expedition reports. In this case, however, Biosphere Expeditions supported a larger program, run by Conservation Volunteers Australia (CVA) and headed up by a CVA scientist (and author of this report). Hence this comprehensive CVA report also serves as the Biosphere Expeditions report for the 2011 expedition to Western Australia. Thank you to CVA and Glenn McFarlane.

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PO Box 423 Ballarat
Victoria, Australia 3353

Author: Glenn McFarlane - Marine Species Manager, Conservation Volunteers Australia

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Cover photo – flatback turtle hatchling on Eco Beach.

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Through the Coastal Guardians program Conservation Volunteers Australia and Woodside Energy have provided ongoing support for turtle research and monitoring across the northern regions of Australia, including this important endeavour at Eco Beach. Conservation Volunteers Australia is most thankful to Woodside for this national partnership and their support for the protection of endangered marine species.

The management and staff of Eco Beach and Australian Eco Constructions give logistical support annually to this sea turtle monitoring program, for which we extend our thanks. General Manager Jodie Mott and her staff were most supportive of the research teams during our stay in 2011and early 2012.

Biosphere Expeditions attended the first two weeks of the program with volunteers from the UK, Europe, USA and Australia. Conservation Volunteers would like to thank the organisation for their support over the past two years. Excellent national and international media coverage was gained and Dr Matthias Hammer and staff receive our thanks.

The efforts and professionalism of the Research Assistants over such a long nesting and hatchling season cannot be understated, especially Corinne Chambers who was the on ground Coordinator for the program. Corinne was backed up during the 40-night tagging component by Kerry Hadley, Anne Mueller, Julia Reisser, Alan Sumnall and Tony Dingwall. The hatchling component of the program which followed was conducted by Anne Mueller, Simon Rosengarten and Damon Pages-Oliver.
The author would like to personally thank all participating Research Assistants, supporting staff of Conservation Volunteers Australia and the many volunteers who conducted the patrols during the 40 nights of tagging then monitoring over 60 days of hatchling emergence.

See Appendix 2 for further supporters and sponsors

Executive Summary

The nesting population of Australian flatback *(Natator depressus)* sea turtles at Eco Beach continues as the focus of this annual program which gathers valuable data on the species, monitors dynamic changes to the nesting environment and acts as a strong base for environmental teaching and training of all program participants.

Whilst not as high a density Western Australian nesting population as Cape Domett, Barrow Island or the Pilbara region, the Eco Beach population remains significant for the following reasons:

- The 12km nesting beach and survey area is free from human development which can impact on nesting turtles and hatchlings.
- The beach and almost non-existent nesting dune are subject to strong winds and high tides in excess of 10m, which combined results in highly changeable beach dynamics and a loss of nests.
- Satellite transmitter tracking of female flatbacks indicates migratory routes different from those of previously tracked southern stocks.
- High nest temperatures above an expected embryo mortality level continue to produce nest hatch success rates to 100%.
- 88% of flatbacks seen in 2011 were from past tagging years (2008 onwards) and of the 32 remigrants seen over the years, 75% have nested on a one year cycle when a (published) two to five year cycle would be expected.

The Eco Beach Sea Turtle Monitoring Program, managed by Conservation Volunteers Australia (CVA), is a Wild Futures initiative. Wild Futures is working to protect key species including flatbacks and their habitats in this West Kimberley region. Science-based survey work commenced at Eco Beach in October 2008 and continues today.

The flatback sea turtle remains listed internationally as Data Deficient (IUCN Red List of Threatened Species). Flatbacks in Western Australia are listed as Vulnerable. The data gained from the 2011 Eco Beach nesting season will add strength to other existing flatback monitoring programs and in time should enable a more accurate reflection and management of the species.

The 2011 Eco Beach Sea Turtle Monitoring Program tagging component, to which this report primarily relates, produced 202 data registrations comprising 67 nests and 135 false crawls (an incomplete nest with no eggs deposited) over a 40 night period. Despite high beach dynamics and some nest predation by native animals during the nesting and hatchling period, an average of 83% hatchling emergence was recorded from exhumed nests.

Twenty nine individual flatbacks and one hawksbill *(Eretmochelys imbricata)* were identified by the patrols with an interclutch interval of 11 nights between nests for flatbacks, an average of 46 eggs and an average incubation period of 49 days. The hawksbill did not nest successfully and was only sighted once.

Remigrant turtles tagged from past years continued to nest successfully during the 2011 season, with one turtle now seen nesting each year since the program began in 2008. This turtle (tag numbers WA52477 and WA83854) became one of four turtles also fitted with a Platform Terminal Transmitter (PTT). Deployments occurred between 10th and 16th December 2011 utilising flatback turtle harnesses and MK10-AF Fastloc transmitters. The daily progress of these and other tracked flatbacks from the program can be viewed at www.seaturtle.org listed as *CVA - Eco Beach Flatback Monitoring Program.*

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1.0 Introduction

1.1 Background

In 2000, Cyclone Rosita wreaked devastation along the north western Kimberley coastline of Western Australia. The original wilderness retreat, operated by Australian Eco Constructions and located at the bottom of Roebuck Bay south of Broome, was destroyed by the cyclone. Years later at the same location, Eco Beach Wilderness Retreat reopened mid 2009 providing guests and visitors an opportunity to once more connect with the natural environment.

Conservation Volunteers Australia (CVA), in developing the Wild Futures national wildlife conservation program, has a special interest in this region of the Kimberleys. Wild Futures makes a measurable difference to the future of many of Australia's most treasured animals including the Australian flatback sea turtle *(Natator depressus)* which nests on beaches in the Broome region. In addition to the Eco Beach Sea Turtle Monitoring Program, CVA also conducts additional flatback turtle research programs in the region at Cable Beach and at Eighty Mile Beach.

1.2 Eco Beach Sea Turtle Monitoring Program

While flatback turtles were known to nest along the 12km of beach heading north from facilities at Eco Beach Broome, Western Australia (now referred to in this report as the resort for mapping purposes), no known annual or consecutive recording of nesting turtles had occurred until the commencement of the CVA program in October 2008. Anecdotal evidence from the resort Managing Director Karl Plunkett and staff together with past track counts by Dr RIT (Bob) Prince of the Department of Environment and Conservation WA, provided the basis for CVA to establish this annual monitoring program.

While the flatback turtle *(Natator depressus)* is the prime nesting species and hence the focus of the program. Other species such as green *(Chelonia mydas),* hawksbill *(Eretmochelys imbricata),* loggerhead *(Caretta caretta)* and olive ridley turtles *(Lepidochelys olivacea)* are known to inhabit these waters.

The Eco Beach Sea Turtle Monitoring Program for 2011 consisted of two parts:

- The main 40-night tagging component[1] commenced early November and included nest and beach temperature monitoring, early season hatchling emergence and the deployment of Platform Terminal Transmitters (PTT) to track migratory routes of nesting turtles. The 40 nights of patrols were consecutive.

- The 37-day hatchling component[2] consisted of morning surveys to record any late season nesting activity, monitor levels of nest predation and to gain a result of each nest after hatching by conducting an exhumation. The 37 days of morning surveys were not always consecutive.

An excellent overall snapshot of the 2011 nesting season was achieved with the assistance of resort staff who recorded early nesting activity prior to the first CVA research team arriving.

Community education of guests, visitors and staff is a key feature of this CVA Wild Futures program and will remain a focus in future years.

[1] This report focuses on the main 40-night tag and recapture program. There were 14 flatback nests and 15 false crawls (no eggs deposited) as early season nesting activity recorded by resort staff from 9/10/11 to 6/11/11.

[2] Key findings of the hatchling component are included in this report in the Results section. A total of 15 nests and 10 false crawls were recorded as late season nesting activity from 17/12/11 to 17/2/12 with the last nesting activity on 4/2/12.

Figure 1: Locality map showing Eco Beach and the survey area
(Source: Google Earth)

2.0 Methods

2.1 Survey Area

A 12km section of beach (Figure 1) heading north from the resort to Yardoogarra Creek (locally known as Jack's Creek and also in this report for mapping purposes) was the survey area for this program. The resort is located approximately 130km southeast of Broome and near to Cape Villaret. The geographic position of Eco Beach is Latitude 18.32831S and Longitude 122.08279E.

This survey area located at the bottom of Roebuck Bay is rich in invertebrate fauna found throughout the mudflats, which in turn is fed by the expansive Roebuck Plain. The mudflats give way further south to a long coastal beach running to Cape Villaret and beyond. The study area and Roebuck Bay are renowned for the migration of Arctic shorebirds.

The gradient of Eco Beach is generally flat with a high tidal range in excess of 11m throughout the year and 10m during the turtle nesting season. The beach and survey area was geographically divided into three sectors for the program; 1) Resort 2) Cliffs 3) Jack's Creek (Figure 2).

2.1.1 Sector: Resort

This first sector extends from the *Resort* to *Cliffs South* (a distance of 6km). The sector has a small low lying dune area adjoining the beach highlighted by a large, sweeping curved coastline. The dunes are sparse in vegetation with soft, sandstone like low rock structures interspersed. Nesting activity occurs from the high tide mark (which varies greatly) to the occasional nest past the dune amongst the sand and soft rock material. Almost this entire sector is favoured by turtles as a nesting location.

2.1.2 Sector: Cliffs

The middle beach sector is from *Cliffs South* to *Cliffs North* (a distance of 2.5km). This generally straight section of beach butts up against what is mostly vertical rocks and cliff faces to a height of 5m. There is no consistent suitable nesting area where sand meets rock, although nests and false crawls (no eggs deposited) have been recorded annually at this sector. Occasionally a small sand dune to 2m against the cliffs appears throughout the year where nesting activity is restricted. Despite the poor nesting location, some nests survive the tides and hatch.

2.1.3 Sector: Jack's Creek

The final sector is from *Cliffs North* to just before the entrance to *Jack's Creek* (a distance of 3.5km). This is a slightly curved section of beach bordering low dunes and a floodplain which opens to the sea just north of where the Cliffs sector ends. The inlet at the far north end of the beach, locally known as Jack's Creek, is a mangrove area and a popular destination for resort guests and Broome locals for the purpose of Mangrove Jack and Barramundi fishing. The majority of nesting takes place between the high tide mark and the small fore dune. The vegetation covered dune area past the fore dune is also small and unsuited for nesting activity. In most places these narrow dunes adjoin the low lying flood plain. Since this program began in 2008, this sector has been subject to the greatest erosion and subsequent reduced successful nesting.

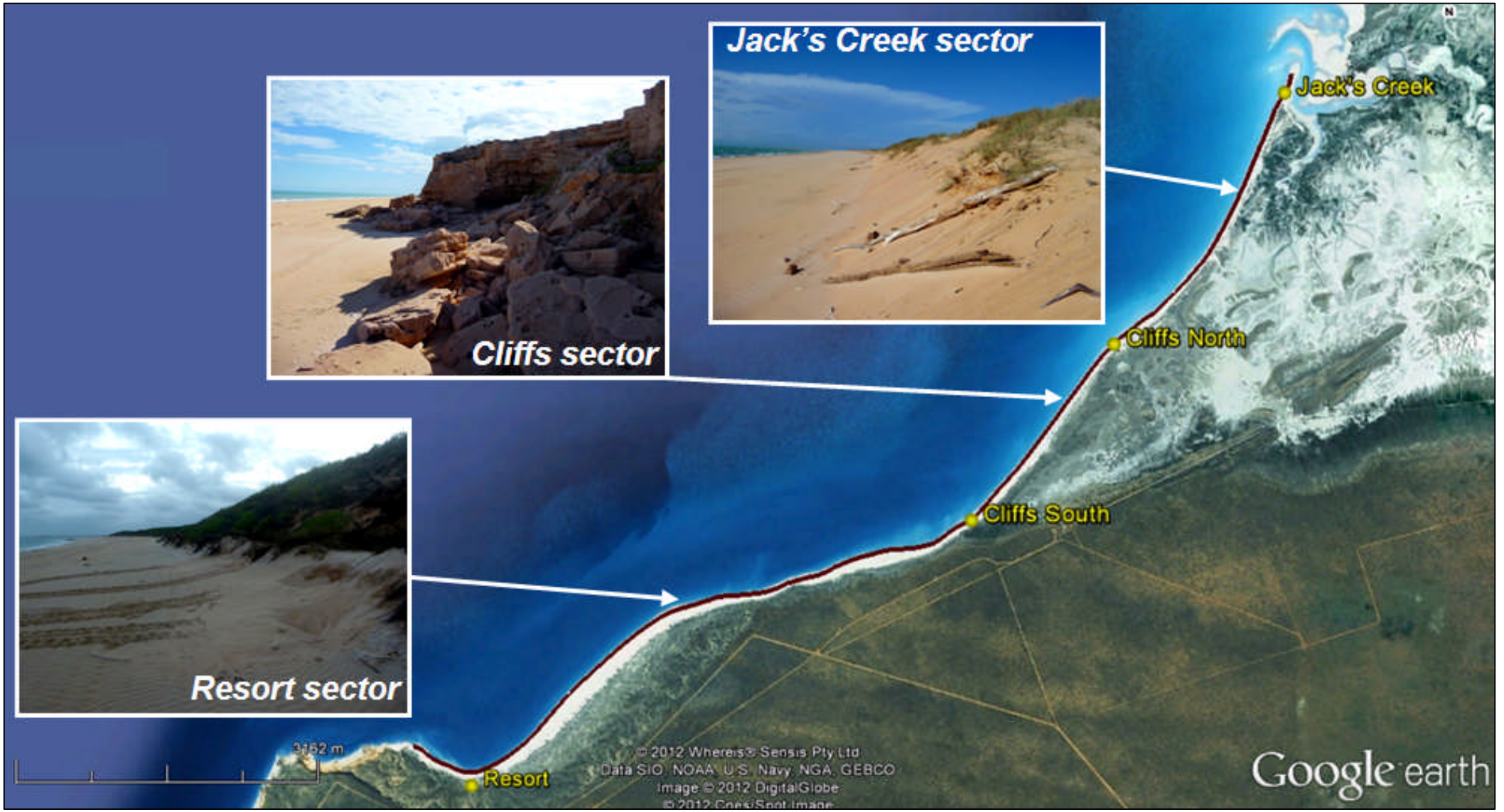


Figure 2: Survey area showing sector beach examples
(Base map: Map Source / Google Earth)

2.2 Patrol days, times and locations

Nightly patrols were conducted from Monday 7th November to Friday 16th December 2011, with a morning survey on the 17th concluding this component of the program (Table 1). The patrol times varied progressing approximately an hour later each night following the high tide. The length of the patrols also varied based on how many turtles were encountered on a sector, but patrols averaged around three hours each night.

Two back to back patrols departed on foot from the Resort sector with one patrol camped out overnight at the Jack's Creek sector. The Cliffs sector was never patrolled at night due to a lower level of nesting activity and unsuitable nesting areas where water meets cliffs. Each day commencing at sunrise, the Jack's Creek sector team completed a morning survey of the entire beach during their return to the resort.

This morning survey, conducted for each of the 40 nights, recorded:

- Nest and false crawl activity after the patrols had finished
- Hatchling emergence
- Interference by predators
- Injured and stranded turtles

In turtle time, the actual date recorded on the data sheets (and used in data analysis for this report) commenced at midday continuing through the night to the following midday. This allowed for a complete snapshot of nesting activity throughout the night regardless of the date change at midnight.

Table 1: Nightly patrols by sector

Date:	7/11	8/11	9/11	10/11	11/11	12/11	13/11	14/11	15/11
Resort – patrol 1									
Resort – patrol 2									
Jack's Creek					1	1	1	1	
	16/11	17/11	18/11	19/11	20/11	21/11	22/11	23/11	24/11
Resort – patrol 1									
Resort – patrol 2									
Jack's Creek				2	2		3	3	1
	25/11	26/11	27/11	28/11	29/11	30/12	1/12	2/12	3/12
Resort – patrol 1						3			
Resort – patrol 2					3	3	3	3	3
Jack's Creek	1	1	1	1	1	1		3	3
	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	12/12
Resort – patrol 1				3					
Resort – patrol 2	3		3	3	3	3			
Jack's Creek	3	2	3					1	1
	13/12	14/12	15/12	16/12					
Resort – patrol 1									
Resort – patrol 2	2	3	2						
Jack's Creek	1	1	2	2					

Table Key:
Grey shading indicates a completed patrol
[1] No patrol at Jack's Creek as tides over 9m washed over the camping area and the majority of the patrol beach
[2] No patrol at Jack's Creek due to the combined deployment of PTTs on the Resort sector
[3] No patrol due to staff, volunteer or vehicle limitations

2.3 Tidal variations

An extensive moon and tidal chart was created for the entire nesting and hatching season from 12th September 2011 to 17th February 2012. This was to enable the patrols and later data analysis to gauge the likely survival of a successful nest based on the wide tidal variations.

Like much of this Kimberley coastline of Australia, where spring and neap tides can be extreme, tide variations can affect the nesting success on Eco Beach. The higher spring tides occur around each monthly New Moon and Full Moon phase, with neap tides taking place around the First Quarter and Third Quarter moon phases.

2.4 Animal handling protocols

Engagement of turtles by CVA Research Assistants and volunteers during the program were in accordance with the WA Department of Environment and Conservation (DEC) *License to take fauna for scientific purposes* held by CVA and was supported by the following documentation:

- DEC protocols for turtle flipper tagging programs
- DEC Animal Ethics Standard Operating Procedures
- Western Australia Marine Turtle Project Protocols
- Australian code of practice for the care and use of animals for scientific purposes
- IUCN / SSC Marine Turtle Specialist Group; Research and Management Techniques for the Conservation of Sea Turtles
- CVA Sea Turtle Standard Operating Procedures

In accordance with most international protocols and to reduce the level of human impact on the natural nesting process when on patrol:

- Research Assistants and volunteers remained behind the head of the turtle, quiet and low except for the restraint of the turtle for flipper tagging and DNA sampling upon her return to the water
- Tags were kept clean and a topical antiseptic such as Betadine was used to sterilise flippers for tagging and DNA sampling
- Surgical gloves were worn when handling turtles, hatchlings and eggs
- No insecticides, perfumes or highly-scented creams were used on patrol
- No flash photography (some photos were taken, but kept to a minimum, for educational purposes during the deployment of the PTTs)

2.4.1 Use of light

To reduce the level of impact and disturbance to the nesting process, all lights had a red filter. It is generally believed that sea turtles on land are near sighted and their degree of vision is limited, however the use of red filters, as opposed to a white light, is less distractive to nesting turtles and hatchlings.

Short wavelength lights such as pure yellow or red, are less disruptive to nesting and hatching sea turtles than sources that emit a substantial amount of short wavelength light e.g. violet, blue, green or any source that appears whitish or golden (Witherington, 1999).

Minimal light was used at all times for the following reasons:

- Light use is a visual distraction to the patrol members when a light, especially a white light, is turned on when walking the beach
- Light is a distraction to turtles attempting to nest
- Hatchlings can become disorientated by light when making their way to the sea

2.5 Data sheets

The 2011 nesting season data sheets adhered to the new Western Australian Marine Turtle Research and Monitoring (WAMTRAM) tagging database.
Research Assistants (nightly patrol leaders) and the volunteers also recorded addition information necessary for this turtle program with a complete list of data (Table 2).

Table 2: Data sheet fields and their significance

DEC tagging data sheet	
Beach	**Location of the monitoring**
Date	**Date the patrol commenced**
Time (24 hour clock)	**Time the patrol located a turtle or nesting activity**
Species	**Which species of turtle located**
Remigrant tag number - left / right	**Flipper tag numbers already in a turtle**
New tag number - left / right	**New tags (or tag) inserted by the patrol**
Tag location / barnacled / fixed / scars	**To help gauge the tag duration and status**
PIT tag – present / location / number	**Passive Integrated Transponder for identification**
CCL (total length and to any notch)	**Measuring the Curved Carapace (shell) Length**
CCW	**Measuring the Curved Carapace Width**
Tagger / Measurer	**Cross check of personnel if required**
Turtle activity when tagged	**Action e.g. digging nest, laying eggs, returning to water**
Beach position	**Location e.g. below high water, above high water, in dune**
Latitude	**To locate nesting activity with GPS**
Longitude	**To locate nesting activity with GPS**
Clutch completed - yes / no / unsure	**Visual confirmation of eggs being deposited**
Egg count	**Statistical purposes**
Injuries checked – yes / no	**Statistical purposes**
Body part (mark damage location)	**To help gauge the health of the turtle**
Damage – minor / major / deformity	**To help gauge the health of the turtle**
Flipper damage (mark damage location)	**To help gauge the health of the turtle**
Comments	**Any additional observations noted**
Additional CVA data	
Code	**Allocated Nest or False Crawl code**
Number of body pits	**To gauge unsuccessful nesting attempts in the dry sand**
Track width	**Statistical purposes and to estimate reencountered tracks**
Turtle seen: Yes / No	**To gauge the success of the patrols, help determine activity**
Nest depth	**To gauge sand erosion or accretion upon exhumation**
Nest width	**Statistical purposes, correlation to nest depth, track width**
DNA number	**Vial number for genetic analysis of flipper tissue**
Data logger number and time In / Out	**Nest temperature data logger to assist sex ratio determination**

A separate standardised data sheet was used to record mortality and strandings on the beach with the information provided to DEC.

CVA exhumation sheets were used to record the fate of each nest marked during the program.

2.6 Tagging

External tags were inserted in the front flippers of all untagged turtles. The self locking titanium tags do not corrode or irritate the skin or flesh of the turtle. The tags used on the program during 2011 were purchased from Stockbrands (Figure 3) with a DEC numerical range for the program since inception of WA30529 to WA83900. During the 40 nights, 13 new flatbacks and one hawksbill turtle were tagged with two remigrant turtles receiving missing single tags.

Wearing surgical gloves, Research Assistants first inspected the turtle for existing tags or scars. Existing tags were cleaned of barnacles and algae and checked for skin growth or restrictions. Prior to tag insertion, the numbers were recorded on the data sheet, tags individually prepared and the area of the flipper sterilised on both sides. The lowest numbered tag was inserted first into the trailing edge of the left flipper, centre of the first scale out from the axilla (the armpit). The same position and process was used for right side flipper tagging (Figure 4).

Figure 3: Pliers and titanium tags

Figure 4: Position of the right side tag

2.7 DNA sampling

As no previous tagging or DNA sampling had been undertaken on flatback turtles in this part of WA prior to the commencement of this program, it was essential that suitable samples of skin continued to be collected for genetic analysis.

Sampling was done at the request of the Institute for Applied Ecology, Faculty of Applied Science at the University of Canberra. DNA samples were taken from all encountered nesting turtles.

After the nesting or false crawl processes were complete, a small area of skin was sterilised on a rear flipper of each turtle and a sample approximately 4mm x 4mm was removed and placed in a vial containing a preservative solution. The affected area was checked for any bleeding and the turtle released.

A total of 19 DNA samples were taken from *Natator depressus* and one sample from *Eretmochelys imbricata*. Turtles on which PTTs were deployed were also sampled if for the first time.

2.8 Biometrics

Each turtle encountered was measured when covering the nest after the egg laying process was complete or when returning to the sea. Measurements were taken three times to ensure accuracy. Only the length and width of the carapace (shell) were measured in millimetres, not the overall length of the turtle (Figures 5 & 6). Longitudinal measurements were taken from a central point of the carapace near the head to the middle of the notch found at the end of the carapace (CCL: curved carapace length). The widest point of the carapace was also recorded (CCW: curved carapace width).

Figure 5: Measuring the CCL – Natator *depressus*

Figure 6: Measuring the CCW – *Natator depressus*

A body inspection of each turtle was conducted to record any scars or pieces missing from all four flippers, the presence of any barnacles or parasites, any body or shell deformations and also to note the successful excretion of salt as fluid from the eyes.

Additional measurements and data were taken such as the track width of the front flippers, the nest depth and width, location of the nest relative to the water, whether it was a new or remigrant tagging and the number of body pits per nesting attempt.

2.9 Nest marking

Successful nests were only recorded using GPS during the initial 2008 program, however in 2009 and 2010 all nests were triangulated with measurements, compass bearings and beach markers then a bamboo stake and tag placed 1m behind the nest entrance. The 2011 program ceased triangulation and all nests were recorded with GPS with the bamboo stake and tag place 1m directly behind where the Research Assistant had best determined the nest entrance at the time (Figure 7).

Figure 7: Nest marker behind a hatched nest

2.10 Data loggers

Temperature data loggers were deployed in five flatback nests during the incubation period, plus two additional loggers have been permanently buried at nest depth at either end of the survey area.

In each of the five nests, two DS1922L Thermochron iButtons (High Resolution 8kb / ±0.01°C) were attached to a cord at set intervals and lowered into the nest as the turtle commenced the egg laying process. No disturbance to the turtle or interruption to the eggs laying process was observed.

The first iButton was placed at the bottom of the nest and the second iButton located 25cm higher up the cord, which was then laid on the sand surface to allow the turtle to cover and camouflage the nest. The cord was later buried in a small sand channel and attached to a false marker next to the bamboo nest marker and tag. This eliminated the possibility of the bamboo nest marker being removed by external forces during incubation and damaging the nest. All ten temperature data loggers (two per nest) were recovered during the exhumation process (Figure 8). The data loggers were programmed to record hourly nest temperatures.

Figure 8: Removal of data loggers during exhumation

The purpose of the iButton data loggers located in nests was to gather data relative to successful embryo development and to indicate whether a nest has produced all males, all females, or a split of the sexes.

As a characteristic of TSD (Temperature-dependent Sex Determination), the pivotal temperature of turtle eggs is the constant incubation temperature that produces equal numbers of males and females. The pivotal temperature during the middle period of incubation determines the sex of the hatchlings and the subsequent male / female ratio of the nest. Limited studies in this field have been published for flatback turtles, although the pivotal sex temperature has been noted at 29.3ºC (Limpus, 1995).

Warmer nest temperatures produce predominantly females while cooler temperatures result in more males. The pivotal temperature for each species of marine turtle varies slightly, not only by the number of degrees, but also by geographical regions around the world where a turtle species nests. The survey area has recorded only flatback turtles successfully nesting during the first four years of the program. A definitive pivotal temperature for this species is yet to be determined.

The two additional single data loggers were deployed at either end of the survey area as part of a long term study by CVA to monitor any changes in climate at this nesting beach. One DS1922L Thermochron iButton was buried in 2009 on the main Resort sector nesting area at a depth of 70cm. The same process was repeated at the main Jack's Creek nesting area. Hourly beach temperature data is uploaded every six months.

2.11 Platform Terminal Transmitters

The Research Assistants and volunteers deployed four PTTs during the program. Mk10-AF Fastloc GPS transmitters from Wildlife Computers were used (Figure 9), tracked through the Argos system and displayed on www.seaturtle.org for public viewing.

Each pre-programmed PTT contains lithium batteries which power the transmitter to emit a VHF signal to the nearest passing Argos satellite when the turtle surfaces to breathe. This occurs when the small antenna on the PTT comes in contact with the air. With software updating the location of a tracked animal daily, a range of data can be obtained depending on the type of transmitter and the sensors required. The sensors on the Mk10-AF Fastloc GPS deployed in 2011 included dive depth and duration, sea and surface temperature and light levels. The PTTs were expected to transmit for more than one year and a full analysis of the results is outside the scope of this report.

One of the main gains from deploying PTTs on nesting sea turtles is to track migratory movements from nesting to foraging to mating grounds as the life cycle of the adult turtle continues. Effective tracking can lead to the effective management of turtle stocks which can often cross international waters.

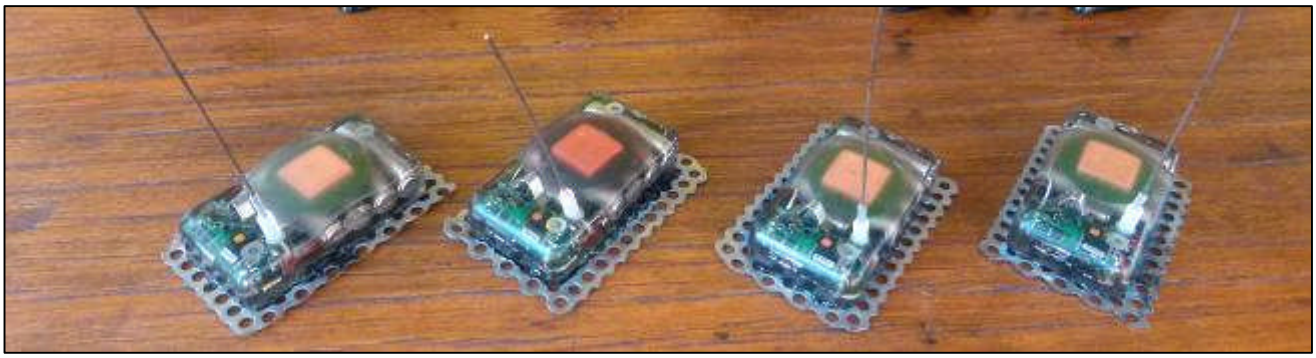


Figure 9: 2011 Eco Beach PTTs – Mk10-AF Fastloc GPS

The conventional method of gluing transmitters to hard-shelled turtles using epoxy resin fails on flatback turtles as they, similarly to leatherback turtles (*Dermochelys coriacea*), have a carapace covered by a soft and easily abraded skin (Sperling, 2004). Four specially made harnesses were used for the Eco Beach transmitter deployments. The first step was to epoxy glue each PTT to the harness base plate and then cover with anti-fouling paint to help prevent biofouling of the sensors (Figure 10).

Figure 10: PTT attached to base plate

Once the PTT was glued to the base plate and allowed to set for 24 hours, the transmitter was then tested before attachment to the turtle and harness soon afterwards.

The flatback turtle was allowed to complete the nesting process as Research Assistants and volunteers prepared the harness by taping it into position on an upturned 68 litre Nally Australia plastic storage bin to hold the weight of the turtle. The harness consisted of a central round metal ring, which was located underneath the turtle on the plastron, with six seatbelt-type webbing straps leaving the ring and passing around the front and rear flippers plus both sides of the turtle.

The turtle was quickly restrained and lifted on top of the plastic box and the central harness ring. Straps were threaded through the base plate and adjusted with Velcro and metal clips to secure it in place (Figure 11).

Figure 11: Harness positioning

Each flipper was checked for a complete free range of movement before final adjustments were made to the harness, the transmitter activated and tested and then the turtle released. CVA Research Assistants and volunteers have been able to complete a PTT attachment and deployment using this method in just nine minutes.

The transmitter duration depends on a number of factors including the repetition pulse rate pre-programmed into the PTT, battery life, biofouling of sensors, loss of the PTT from the carapace or the death of the turtle e.g. natural causes, hunting, fishing industry bycatch, or the environment in which the turtle inhabits e.g. open water or rocky reefs.

The type and gauge of metal used in the harness ring is designed to corrode in salt water and coincide with the expected transmitter internal battery depletion. The harness then falls off the turtle and sinks, preventing further transmissions.

3.0 Results

An analysis of the data recorded during the annual survey period. The data, charts and graphs that follow, unless indicated, are for the 40-nights of patrols.

3.1 Nest and false crawl activity

202 data registrations (67 nests and 135 false crawls) were recorded during the tagging component of the program (Figure 12) from 7/11/11 to 16/12/11. All were from flatback sea turtles except for one false crawl from a hawksbill turtle.

Before and after this 40-night tagging survey, 29 additional nests and 25 false crawls were recorded to complete the entire season. Nesting activity at the beach commenced on 19/10/10 which was five nights later than in 2010. Nesting activity concluded on the 4/2/12 which was 29 nights later than in 2010.

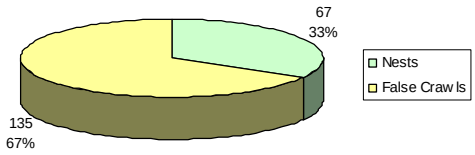


Figure 12: Nesting activity

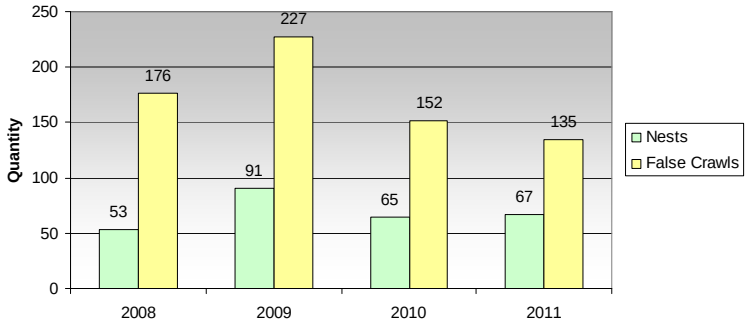


Figure 13: Nesting activity 2008 - 2011

The level of activity for the first four years of the monitoring program (Figure 13) and one may expect to this point different turtles nesting each year. This however was not necessarily the case and is explained in section 3.3.2 Remigrant turtles.

The ratio of false crawls (unsuccessful nesting) to successful nesting attempts was 3.3 to 1 in 2008; 2.5 to 1 in 2009 and 2.4 to 1 for 2010. This figure continued to decrease during 2011 to 2 false crawls for each successful nesting. Flatbacks in this region choose to nest at the end of the dry season when rainfall is minimal and often when the last good rains were observed some eight months earlier. Increased moisture in the nesting areas prior to season commencement means the turtles are able to have the nest chamber hold in the dry sand which is constantly buffeted by harsh and dry winds.

As part of the nesting process a turtle clears an area of sand of all debris and begins recessing herself slightly below the beach level. This is called the body pit. The number of body pits was recorded for each nesting attempt (Table 3) as an indicator of annual nesting conditions. During the 2011 program, turtles averaged 1.5 body pits each visit to the beach.

Table 3: Frequency of body pits

Number of body pits	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12 **
Number of times	**33**	**93**	**44**	**14**	**12**	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**1**

** 12 nest chambers were dug across multiple attempts by a turtle missing a rear flipper*

A false crawl takes two forms; where the turtle exits the water and makes no attempt to nest, or where single or multiple body pits or nest chambers are made without depositing the eggs.

Due to dry sand, many turtles were observed abandoning collapsing egg chambers and moving closer to the high water mark each time. This pattern generally continued until the turtle found more moist sand suitable for the nest shape to hold and then deposited the eggs.

3.1.1 Location of nesting activity

Activity was spread along the entire 12km of the survey area (Figures 14 & 15) and mirrored previous years.

There were two main nesting areas on the Resort sector with 18% of total nests recorded over 650m and a further 16% of nests located on a stretch of beach 1km long. Nesting on the Jack's Creek sector in 2011 saw a return of the turtles favouring the most northerly end of the sector 28% of nests across 1.5km. For the first time in the program's history nests were deposited in a 640m section of beach around Cliffs South (n=3).

Figure 14: Distribution of nests - 2011
(Source: Map Source / Google Earth)

The locations of the 135 false crawls were fairly even across the survey area (Figure 15) and mirrored the key nesting areas.

Figure 15: Distribution of false crawls - 2011
(Source: Map Source / Google Earth)

3.1.2 Nesting activity per sector

The Resort sector distance of 6km yielded 34 nests and 47 false crawls. The Cliffs sector of 2.5km recorded 11 nests and 13 false crawls, while the Jack's Creek sector of 3.5km recorded 22 nests and 75 false crawls (Figures 16 & 17).

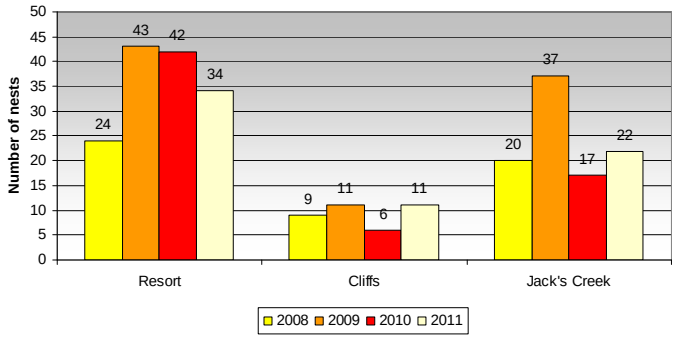


Figure 16: Annual trend of nests per sector

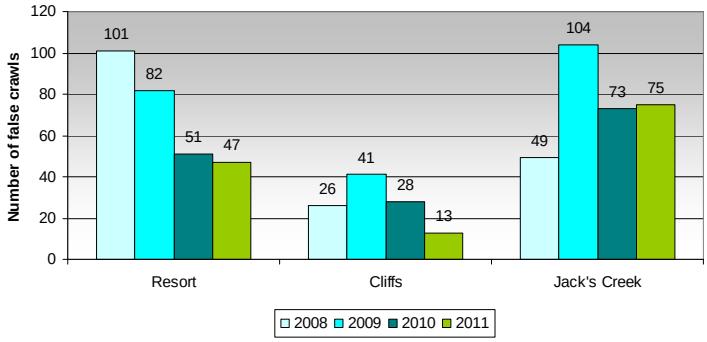


Figure 17: Annual trend of false crawls per sector

It is not known exactly why a turtle chooses a particular place to exit the water, make her way up a beach, find a suitable nesting site to make a body pit and then dig the nest to deposit the eggs. Visually there appeared to be little topographic difference between subsectors within the defined survey area of the beach deemed suitable for nesting. A long term and in depth study of nesting activity per sector is outside the scope of this report. It should also be remembered that the survey area may have different individuals nesting each year.

The ratio between the numbers of nests against false crawls on many sea turtle projects would see a greater number favouring nests, for example at the flatback nesting location of nearby Cable Beach in Broome which CVA also monitors. But this trend has not been the case at Eco Beach during the first four monitoring years, most likely due to the harsh winds and drier sand condition during this time of year when the flatbacks are nesting. The number of false crawls in 2011 outweighed the number of nests by 2:1.

3.1.3 Position of the nests relative to the sea

Turtles generally nest at different locations and beach positions each time they return to a beach. At Eco Beach, some favour nesting nearer the vegetation, some on the high tide sandbank and others at the high tide mark. Nest position results relative to the sea for the 2011 season indicated the turtles favoured the part of the beach located on the front edge of the spinifex or dune (Figure 18).

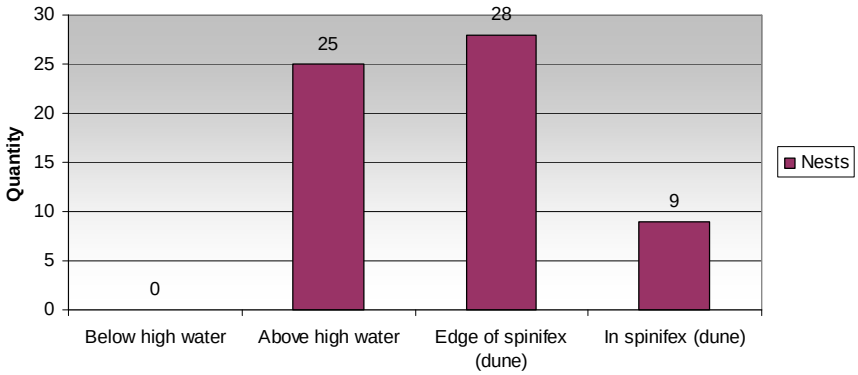


Figure 18: Position of nests relative to the sea

As in previous years, a significant number of turtles during 2011 tried to nest in the sparse vegetation and dune system, but moved closer towards the water after each abandoned attempt to enable the nest chamber to hold in the dry sand. Monthly spring tides in excess of 10m during the nesting and hatchling season, together with the onset of the cyclone season, meant many nests were ultimately washed away as turtles nested closer to the nightly high tide mark throughout the course of monthly tidal fluctuations.

The graph in **Figure 18** utilising standard data sheet nest positions does not tell the complete story as the dynamics of Eco Beach across the 12km of the survey area varies greatly. Many parts of the Resort sector do not have any vegetation or dune, with sand giving way to long stretches of fragile rock plateaus. The Cliffs sector has mostly waves hitting cliff faces with no dune system at all and Jack's Creek sector has a combination of narrow vegetation, dune and rocks for a nesting area.

3.1.4 Number of eggs

Visual egg counts were made of 26 nesting turtles without disturbance to the process or removal of the eggs from the nest. Fifteen complete nest counts were recorded plus two incomplete counts as the turtle had already commenced laying when located. Of the total 691 eggs from complete counts, none were identified as infertile being vastly smaller in size and a different shape to that of a fertile egg.

Due to the fragility of nest chambers because of dry sand conditions and the susceptibility of flatbacks to disturbance, no attempt was made during this program to remove a sample of 10 eggs for measurement and weighing. The average number of eggs deposited was 46 (47 in 2010 / 46 in 2009 / 50 in 2008), with a range of 33 to 58 per nest.

3.2 Turtle biometrics

These results represent factors relating to the physiology of nesting Eco Beach flatbacks.

3.2.1 Nest depth and width

The average depth of the nests was 41cm (n=11) with an average width of 19cm (n=6).
Due to the fragility of the nest environment and because the large carapace of a flatback often restricts access to the nest, depth measurements were not always able to be gained. The depth measurement (Table 4) was taken from the bottom of the nest chamber at the rear, to underneath the rear of the carapace behind the cloaca of the turtle. Width was taken by measuring across the widest point of a healthy rear flipper.

Table 4: Individual nest depth and width (cm)

n	1	2	3	4	5
Depth	40	46	29	43	35
Width	21.5	17	17	18	18

There was no strong biometric correlation between the depth of the nest and the width of the rear flipper used to dig the nest ($R^2 = 0.0202$).

3.2.2 Curved Carapace Length

Each time a patrol located a turtle, even if previously encountered, the same set of measurements were recorded. The curved carapace length (CCL) was taken using a flexible fiberglass measuring tape. A total of 28 individual flatbacks and one hawksbill were measured during the program with many flatbacks measured on multiple occasions. See section **3.8 Other species** for the hawksbill turtle details.

Two types of CCL measurements were taken for the DEC tagging datasheet; a measurement to the longest point of the carapace, and a measurement to the central end notch of the carapace. Results given here represent measurements to the notch. (Note: two individuals did not have a carapace notch)

The average CCL was 88.3cm (sd = 2.6) with a range of 84cm to 95cm (Figure 19).

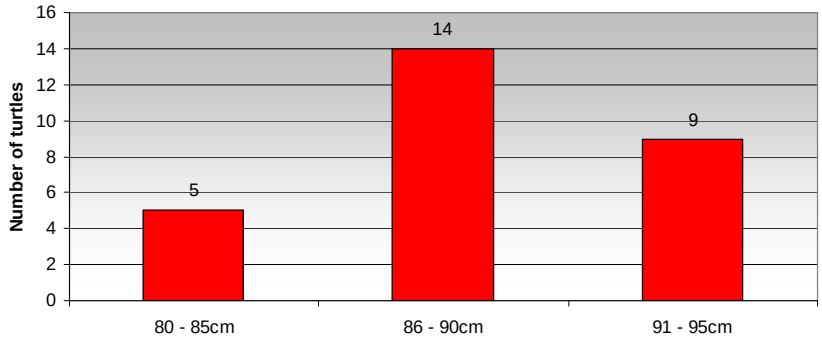


Figure 19: CCL measurements for 2011 Eco Beach flatbacks

3.2.3 Curved Carapace Width

The average curved carapace width (CCL) was 73.8cm (sd = 2.2) with a range of 70cm to 80cm (Figure 20).

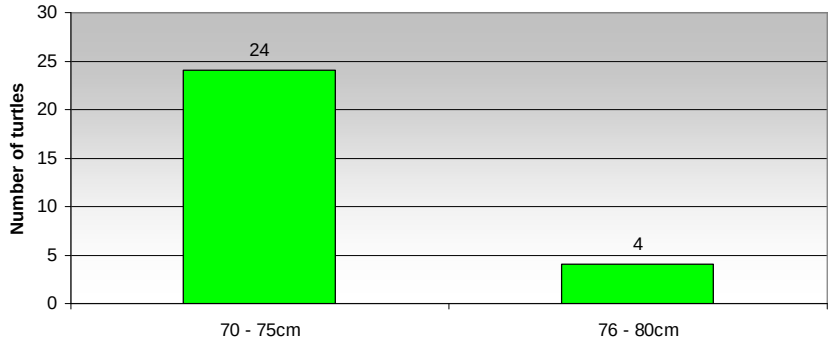


Figure 20: CCW measurements for 2011 Eco Beach flatbacks

The 28 flatbacks measured during 2011 did not show a strong relationship between CCL and CCW (Figure 21).

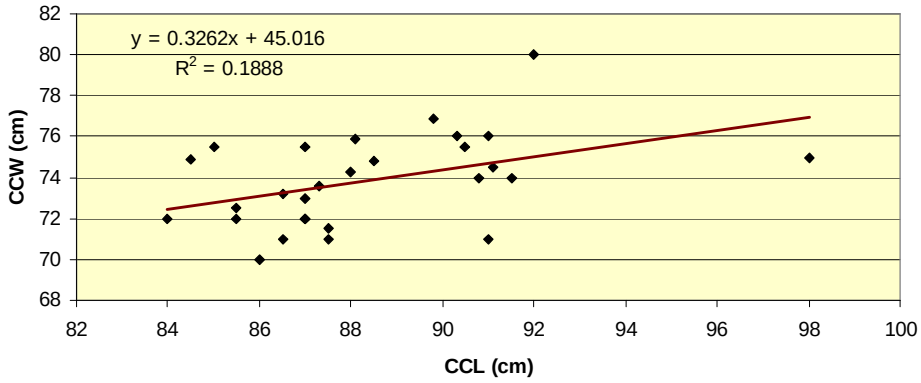


Figure 21: Relationship between CCL and CCW for 2011 Eco Beach flatbacks

3.2.4 Track width

Turtle track measurements were taken on flat sand from the widest points of the front flippers. Track width was recorded for 193 of the 202 data registrations (includes one hawksbill). This helped at the time to estimate the number of individual turtles that may have visited the beach or were due to return for each of the 40 nights of monitoring. Some turtles were observed on the beach at least twice during the same patrol and may have, for example, false crawled on the first sighting and then nested on the second.

192 track width measurements were recorded from flatback turtles seen on patrol for nests and false crawls, plus turtle activity recorded on the morning survey where the turtle was not seen. The average track width was 97.3cm (sd = 6.8) with a range of 70cm - 116cm.

Of the 28 turtles where CCL, CCW and track width were recorded, there was a poor relationship between track width and CCL (R^2 = 0.015) but a slightly greater relationship between track width and CCW (R^2 = 0.1645).

3.2.5 Inspection of turtles

Observations of the flippers, the head (including the eyes), the carapace and the general body structure were taken by the patrols to gain an overall picture of the external health of the turtle. A turtle may have pieces missing from the front and rear flippers which could be the result of mating wounds or attacks by fish such as barracuda and sharks. Carapace scratch marks may be due to mating scars or the turtle inhabiting a particular type of marine environment, for example, a reef or rock protrusions.

Inspections were carried out for all 28 individuals with 15 turtles recorded as having damage. Most damage to the flippers was categorised as minor cuts. Two turtles had both previous tags torn out and new pairs were replaced during the survey. No fibropapilloma tumors were identified. Overall, the Eco Beach stock appears externally to be relatively healthy (Table 5).

Table 5: Body damage of individual turtles

*Flippers **						*Carapace **	
Front left	*Front right*	*Rear left*	*Rear right*	*Tag scars*	*Tags barnacled*	*Edge notches*	*Severe deformity*
1	***3***	***2***	***1***	***7***	***8***	***9***	***1***

** Denotes the subcategory frequency of damage as viewed by standing behind the turtle*

3.3 Nesting trends

An analysis of data relating to the frequency and interval periods of individual turtle nesting behaviour.

3.3.1 Nesting intervals

Tagged turtles were encountered numerous times on the beach sometimes first as a false crawl and then later completing a nest. Often turtles were seen false crawling but not nesting within a night or two, so it was assumed they nested successfully after the initial encounter and were not seen, or nested somewhere nearby outside the survey area.

Three individuals (of the 26 seen multiple times) were visually recorded as completing consecutive nests during the 40 night monitoring program. Two additional flatbacks were observed completing a nest twice within the survey period but with 21 and 34 night intervals respectively. The average interclutch interval for observed flatbacks nesting at Eco Beach during 2011 was 11 nights (Table 6).

Table 6: Interclutch intervals for 2011 Eco Beach flatbacks

Tag numbers (Left)	Tag numbers (Right)	Date	Time	Body pits	Clutch count
WA83813	WA83814	8/11/11	2105	1	Found laying
WA83813	WA83814	20/11/11	2115	1	Found laying
	Interval:	12 nights			
WA83892	WA83893	10/11/11	2005	2	No count possible
WA83892	WA83893	20/11/11	2115	1	37
	Interval:	10 nights			
WA83887	WA83895	17/11/11	0030	1	56
WA83887	WA83895	29/11/11	2323	1	37
	Interval:	12 nights			
WA52477	WA83854	24/11/11	0053	1	40
WA52477	WA83854	15/12/11	0015	1	57
	Nights since seen nesting:	21 nights			
WA48720	WA49245	17/11/11	2230	2	46
WA48720	WA49245	21/12/11	2100	1	Found laying
	Nights since seen nesting:	34 nights			

A sixth individual (WA39255 / WA49940) was seen three times but has not been included in Table 6. This turtle was seen depositing eggs (19/11/11, time 2002, 1 body pit) and then false crawling 11 nights later (20/11/11, time 1930, 1 body pit). Most curiously was that she then was seen laying only six nights later (26/11/11, time 2110, 2 body pits) giving an interval between observed nests of 17 nights, as opposed to the program average of 11 nights.

All six turtles returned to nest each time on the Resort sector with only one turtle having a significant distance between her nests (Table 7). It should be remembered that the nesting beach is 12km in length.

Table 7: Distances between interseasonal nests

Tag numbers (Left)	Tag numbers (Right)	Sector	Distance between nests (metres)
WA83813	WA83814	Resort	815
WA83892	WA83893	Resort	445
WA83887	WA83895	Resort	21
WA52477	WA83854	Resort	355
WA48720	WA49245	Resort	2,000
WA39255	WA49940	Resort	720

3.3.2 Remigrant turtles

Nesting turtles are generally classed as either neophytes or remigrants.

A neophyte turtle is one which is in its first reproductive season. This is very difficult to distinguish without an internal laparoscopy to determine first-time breeding capabilities. For tag and release programs, the term is often used for females with no tags and that have not previously been recorded nesting at that location. The female may be smaller in size, be clean of flipper or body marks and scars and have no previous tags or indication of tagging. Once tagged and seen repeatedly nesting within the same season, the turtle is then referred to as a renesting or interseasonal turtle.

Remigrant turtles are those which have a tagging history of two or more seasons recorded at the same program or at multiple program locations.

Published documentation referencing the nesting cycle for flatbacks in Western Australia is limited and incomplete. While flatbacks are regarded as being able to nest at two year intervals as recorded at projects in QLD, NT and WA, 15 - 30% of WA flatbacks have a remigrant interval of one year (pers comm. Dr RIT Prince, 2010).

Tagged turtles at Eco Beach were encountered returning on many occasions during the 40 nights of monitoring, with combinations of completed nests and false crawls. Due to the length of the nesting beach (12km) and the Cliffs sector not patrolled, there were many identified nests where the turtle was not seen. It is anticipated that she had returned to nest within two nights of first false crawling. Many tagged turtles have been sighted annually on one occasion only and logic dictates that these turtles had migrated back to the beach for the sole purpose of nesting. These points should be considered when analysing the data below which references only repeated visual confirmations of egg depositing per turtle, such that overall remigrant numbers are likely to be much higher than stated here.

In the first four years of the program, 106 individual flatbacks and one hawksbill was flipper tagged.

A full analysis of Eco Beach remigrants and nesting trends are outside the scope of this report, however 88% of tagged flatbacks seen in 2011 were from past years (Figure 22) and of the 32 remigrants seen over all years, 75% have nested on a one year cycle.

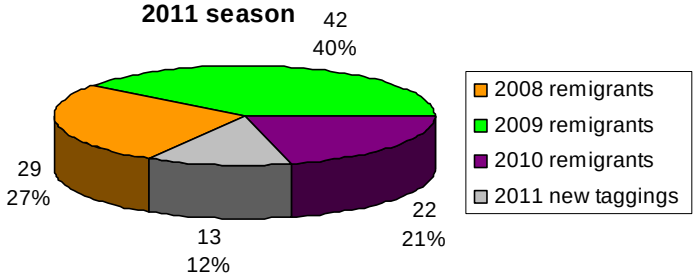


Figure 22: Tagged nesters at Eco Beach – 2011 season

One remigrant had new flipper tags inserted both sides during the 2011 survey and was the first turtle in four years seen to have lost both tags.

3.3.3 Nesting peak

Monitoring for 40 nights enabled more than one full moon and monthly tide cycle for any correlative nesting observations to be made. Spring and neap tides at this beach vary greatly over a month with 6.29m for a *neap high tide* and 9.85m for a *spring high tide* as examples from the 2011 monitoring period. Two Full Moon, one Last Quarter, one New Moon and one First Quarter phases were observed during the 40 nights.

Nightly nesting activity during the monitoring period peaked at 14 data sheets on 29/11/11 which was four nights after the solitary New Moon phase (Figure 23).

By comparison, zero nesting activity was recorded on 12/11/11, 2/12/11 and 14/12/11.
The 2/12/11 correlated with the solitary First Quarter moon phase, which in the previous year the same phase twice recorded the least nesting activity during that survey period.

Outside the scope of this report, a deeper analysis of tidal fluctuations and moon phases relative to nesting activity at Eco Beach is being conducted. However it is worth noting the main nesting periods for the first four years of the program (Table 8). These results signify main nesting periods taken from annual three night averages of nesting activity.

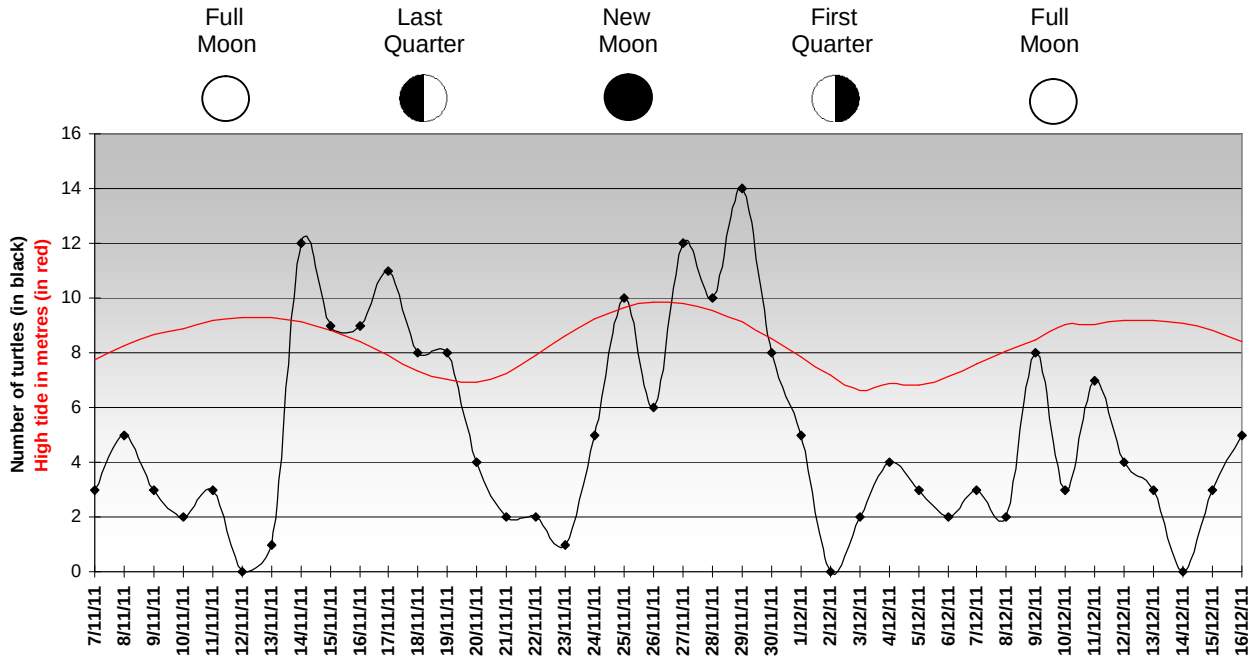


Figure 23: Nesting activity over 40 nights relative to moon and tide

Table 8: Eco Beach main nesting periods 2008 to 2011

Year	*Number of data registrations*	*Criteria**	*Main nesting period dates*	*Number of consecutive nights criteria met*
2008	**229**	**8 turtles**	**29th November to 2nd December** **4th to 8th December** **15th to 17th December**	**4** **5** **3**
2009	**318**	**10 turtles**	**9th to 19th November** **5th to 10th December** **13th to 15th December**	**11** **6** **3**
2010	**217**	**8 turtles**	**27th November to 3rd December** **7th to 10th December**	**7** **4**
2011	**202**	**8 turtles**	**15th to 18th November** **26th to 30th November**	**4** **5**

** Equal to or greater than, for the number of turtles per night taken from a three night average*

3.4 Temperature data loggers

Thermochron DS1922L iButtons (High Resolution, ±0.01ºC) were deployed at the survey area from 17th November to 13th December 2011 in five nests. Two permanent beach data loggers have also been in place at nest depth since 10th December 2009.

3.4.1 Nest data loggers

Ten loggers were placed in nests (two per nest) at set depths with the bottom logger at the lowest point of egg placement and the top logger 25cm higher. Each turtle's nest depth dictated at what beach depths the loggers recorded hourly temperatures (Table 9).

Four nests were located on the Resort sector and one nest on the Jack's Creek sector. Although more nest loggers were desired at the Jack's Creek sector, turtles at the time did not nest at locations which would have survived subsequent high tides during incubation.

Table 9: Nest and data logger results (Celsius) for the 2011 Eco Beach season

Nest code	Date in	Date out	Number of days logged	Nest depth at the time	Nest depth at exhumation	Minimum temp.	Maximum temp.	Average temp.	Std. Dev.	Hatch success rate
DL1 top	17/11/11	11/1/12 (exhumation date)	55			25.89	35.13	33.29	1.10	83%
DL1 bottom				45cm	64cm	26.69	34.81	33.15	1.06	
DL2 top	26/11/11	22/1/12 (exhumation date)	67			28.90	35.39	32.98	1.41	63%
DL2 bottom				49cm	55cm	29.45	35.62	32.97	1.49	
DL3 top	30/11/11	25/1/12 (exhumation date)	56			24.00*	54.66*	33.38*	6.70	Unknown*
DL3 bottom				38cm	Not recorded	24.20*	53.35*	33.30*	6.70	
DL4 top	13/12/11	29/1/12 (hatch date)	47			28.84	34.64	32.91	1.20	Unknown (hatched then predated)
DL4 bottom				29cm	71cm	29.39	34.19	32.79	0.90	
DL5 top	11/12/11	29/1/12 (hatch date)	49			28.09	34.08	32.15	1.30	98%
DL5 bottom				46cm	52cm	28.39	34.00	32.27	1.16	

** Nest washed out with logger remaining*

All nest data loggers, with the exception of DL3 (top and bottom), were consistent in their paired recordings.

In 2009, all loggers recorded the same coolest and warmest dates and in 2010 results varied with five separate dates. The 2011 analysis showed three separate occasions as the coolest and warmest dates. Temperatures as a generalisation were warmest in the hours before sunrise and coolest late mornings.

3.4.2 Sex determination of Eco Beach hatchlings

As a characteristic of TSD (Temperature-dependent Sex Determination), the pivotal temperature of turtle eggs is the constant incubation temperature that produces equal numbers of males and females. The pivotal temperature during the middle period of incubation determines the sex of the hatchlings and the subsequent male / female ratio of the nest.

Limited studies in this field have been published for flatback turtles, although the pivotal sex temperature has been noted at 29.3ºC (Limpus, 1995). Warmer nest temperatures produce predominantly females while cooler temperatures result in more males. The pivotal temperature for each species of marine turtle varies slightly, not only by the number of degrees, but also by geographical regions around the world where a

turtle species nests. The survey area has only recorded flatback turtles nesting during the first three years of the program. A definitive pivotal temperature for this species is yet to be determined.

Sea turtle eggs rarely develop at temperatures over 34ºC (Miller, 1997) yet annual Eco Beach loggers continue to record constant temperatures at or above this mark on multiple occasions and for extended periods (Table 10). This includes during the pivotal temperature period which has resulted annually in high hatch rates (DL3 loggers have been excluded from Table 10).

Table 10: Percentage of logged nest time at or above 34ºC for the 2011 Eco Beach season

Nest code	Number of days logged	Nest depth at the time	Nest depth at exhumation	% of time at or above 34 ºC	Hatch success rate
DL1 top	55			35%	83%
DL1 bottom		45cm	64cm	31%	
DL2 top	67			28%	63%
DL2 bottom		49cm	55cm	30%	
DL4 top	47			9%	Unknown (hatched then predated)
DL4 bottom		29cm	71cm	2%	
DL5 top	49			1%	98%
DL5 bottom		46cm	52cm	0.002%	

The results from the nest loggers (Table 10) were consistent with those taken during the 2009 and 2010 seasons, with temperatures averaging between 32.86ºC and 33.85ºC during the expected pivotal incubation period.

An analysis of nest temperature data and the known nest hatch success rates for the three seasons shows that embryo development continued to occur when sand temperatures reached and exceeded 34ºC. Temperatures annually were very high during the days that loggers were activated, including during the pivotal temperature period, suggesting a strong female-biased sex ratio. Annual nest logger results of high temperatures were also consistent with those of the two permanent beach data loggers.

3.4.3 Beach temperature data loggers

A logger at both ends of the survey area buried at 70cm has been in place since 10th December 2009. As per the nest loggers, they are set to record hourly sand temperatures for the battery life lasting some years as part of a long term study to record any changes in climate.

The initial Jack's Creek logger was washed away by Cyclone Laurence on 20/12/09 whilst the Resort sector logger failed for a five month period during 2010. Both replacement loggers in place and activated during the 2011 nesting season recorded temperatures consistent with those of the nest loggers for the same period, with a range of 28.14ºC to 34.82ºC.
As with correlating nesting occurrence with tide and moon phases, an in depth study of beach and TSD nest temperatures is outside the scope of this report.

3.5 Fate of the nests

Research Assistants and volunteers remained onsite after the 40-night tagging component, conducting morning surveys to monitor hatchling emergence and exhumations of all nests. This occurred until Eco Beach Resort closed seasonally from early January 2012 and then nest monitoring was followed by multiple two-day trips two days apart, continuing the exhumations. The hatchling component of the program concluded on 17th February 2012.

3.5.1 Beach dynamics

As with 2008, 2009 and 2010 season results, many nests were subject to erosion and being washed away by impending higher spring tides during incubation. With almost half of the Jack's Creek nesting sector washed away by Tropical Cyclone Laurence on 19th December 2009, the narrow foredune system then gave way to exposed rock with the beach dune system to date, slow to return. Successful nest locations during 2010 moved further south down this beach sector, yet 2011 season turtles made a return to the northerly end of the sector with good success, although overall nesting numbers on the Jack's Creek sector have remained down since the 2009 cyclone.

3.5.2 Exhumations

Complete exhumations were conducted on 26 of the 67 nests (Figure 24) and all nests were categorised as:

- *Exhumed* – A completed nest result.
- *Hatched and predated* – Incomplete result due to signs of predation and egg shells located inside and outside of the nest with known egg numbers not tallying.
- *Total predation* – No result and nest destruction.
- *Washed away* – Tidal influences removed the nest.

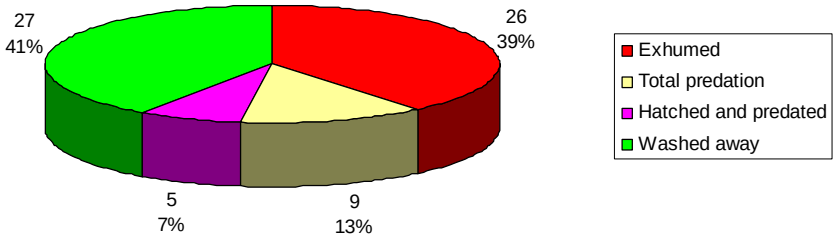
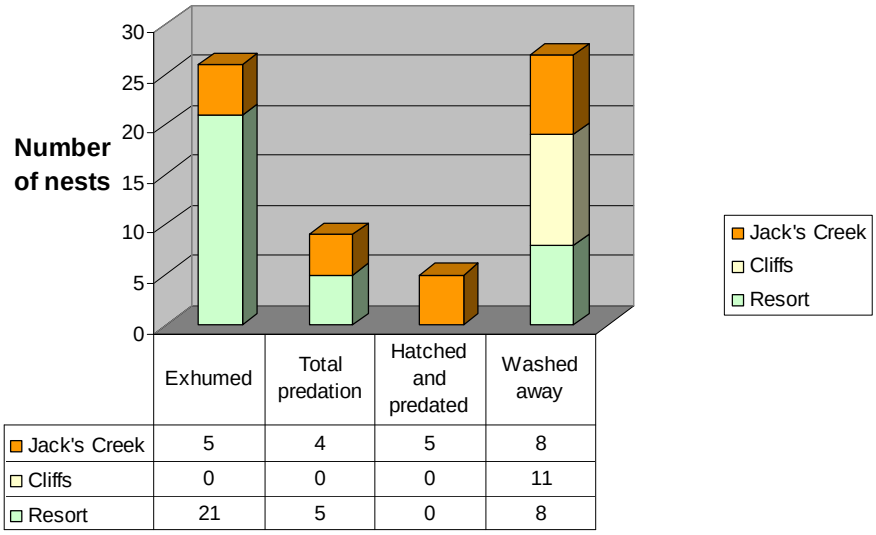


Figure 24: Nest fate

Whilst the program from 2011 onwards has been granted DEC licensing permission to relocate doomed nests (low to high tide nests from turtles viewed by the patrols) to higher grounds, no nests were actually relocated during the 2011 survey. Any decision to relocate doomed nests is based on an extensive tide chart created for the survey area and past program knowledge of the ensuring high spring tides along with beach dynamics during December/January/February.
Unfortunately unexpected late December strong storms surges resulted in a high number of nests for 2011 ultimately being washed away (Figure 24) including all 11 nests from the Cliffs sector.

As with past years, predation by native predators such as large sand goannas *(Varanus spp.)* and canine *(Canis spp.)* was centralised on the Jack's Creek sector and in 2011 accounted for 64% of nests predated during incubation or after hatching (Figure 25).



	Exhumed	Total predation	Hatched and predated	Washed away
Jack's Creek	5	4	5	8
Cliffs	0	0	0	11
Resort	21	5	0	8

Figure 25: Nest fate by sector

The hatch success rate of exhumed nests at Eco Beach for 2011 remained high (Figure 26) with an average of 83%. Hatch success percentages ranged from a low of 43% (n=1) to a high of 100% (n=2).

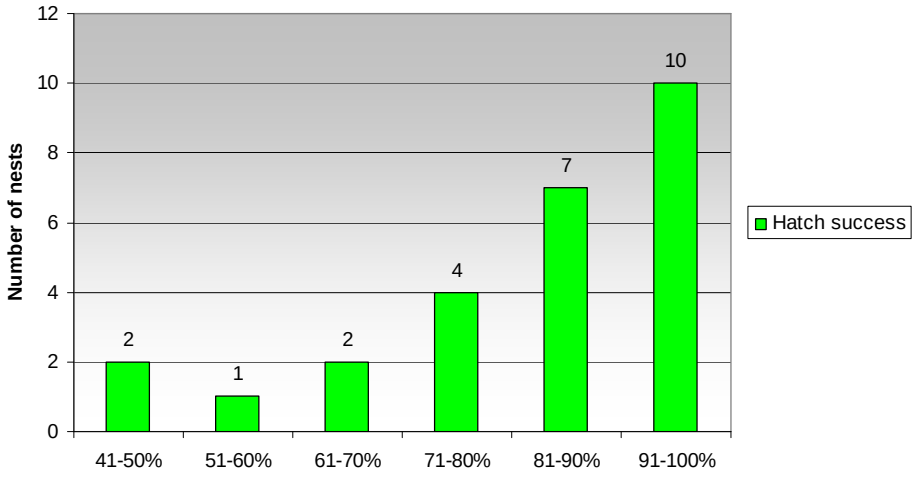


Figure 26: Nest hatch success rates

The average incubation period was 49 nights (n=6) and as was the case in 2008-10, eggs with no embryonic development (Table 11) accounted for the majority of eggs opened (n=233).

Table 11: Nest exhumation results

No development	*Stage 1*	*Stage 2*	*Stage 3*	*Stage 4*	*Maggots*	*Fungus*	*Bacteria*	*Ants*	*Crab*	*Roots*
112	**32**	**28**	**36**	**8**	**0**	**10**	**0**	**0**	**2**	**0**

Explanation of embryonic stages:

- *No development* – No embryonic development was found in the egg.
- *Stage 1* – Where the embryo (including the bloodline and eyes) was up to 25% of the egg mass.
- *Stage 2* – Where the embryo was between 25% and 50% of the egg mass.
- *Stage 3* – Where the embryo was between 50% and 75% of the egg mass.
- *Stage 4* – Where the embryo was between 75% and 100% of the egg mass yet the hatchling remained dead in the shell.

Sixty seven developed hatchlings were found dead in nests and three hatchlings found dead outside nests.

The average nest depth at exhumation (from beach level to the chamber bottom) was 69cm (n=30) and included nests listed as *Hatched and predated*.

3.6 Strandings and mortalities

Two Western Australia Government *Marine Wildlife Stranding and Mortality Reports* were completed during the program, with both sea turtles listed as deceased.

- 39cm (CCL) immature green turtle *(Chelonia mydas)* on the Resort sector on 13/11/11 had sustained a large bite mark to the carapace side
- 45cm immature green turtle on the Jack's Creek sector on 19/11/11

3.7 Platform Terminal Transmitters

Four Mk10-AF Fastloc Platform Terminal Transmitters (PTT) were deployed in December 2011 to compliment past PTT deployments from the 2009 and 2010 nesting seasons. A full study on migratory paths and foraging grounds for all past and future Eco Beach deployments is outside the scope of this report. An indication of the most recent tracking is given (Figure 27) with individual turtle details listed (Table 12).

Table 12: 2011 Eco Beach PTT turtles

Name	Deployment date	Left tag number	Right tag number	Year first flipper tagged	CCL (notch)
The Great Turtle	10/12/11	WA83807	WA83808	2010	86cm
Lesley	14/12/11	WA83890	WA83891	2011	87cm
Trash	15/12/11	WA52477	WA83854	2008	87.5cm
Kurlibil	16/12/11	WA83851	WA83852	2009	87.5cm

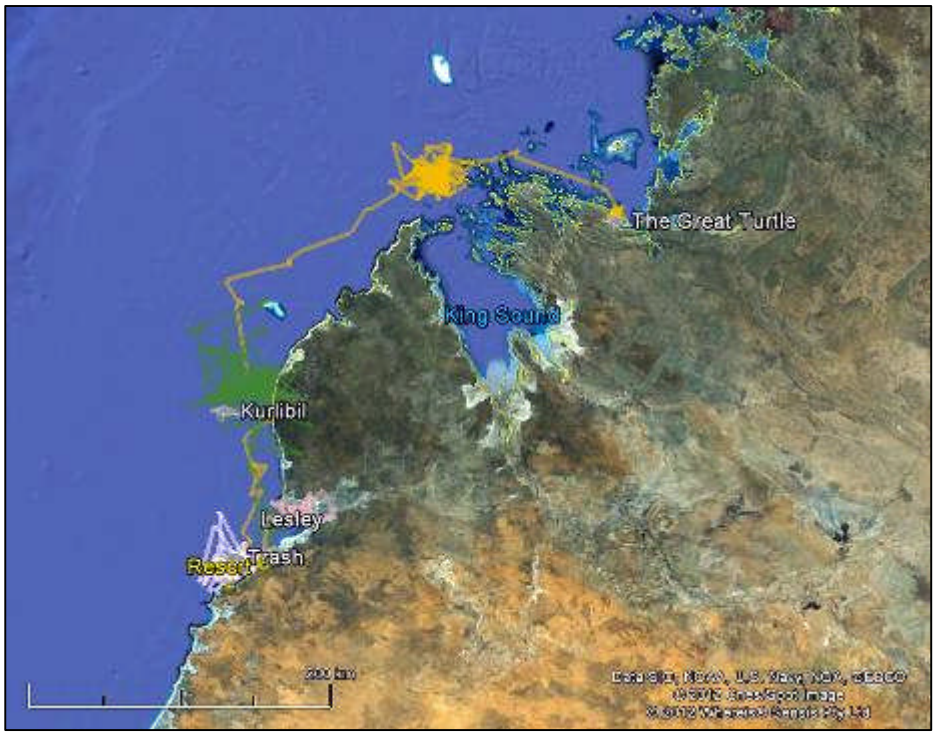


Figure 27: Satellite tracking of four 2011 season Eco Beach flatbacks to 9/7/12
(Source: seaturtle.org STAT / Google Earth)

All Conservation Volunteers Australia tracked turtles from this program can be followed by visiting www.seaturtle.org and searching the Tracking section for *CVA - Eco Beach Flatback Monitoring Program.*

3.8 Other species

For the first time in the program's history, a species other than the flatback turtle was recorded as nesting at Eco Beach during the annual monitoring program.

One hawksbill turtle *(Eretmochelys imbricata)* was seen attempting to nest during the night patrol of Jack's Creek sector on 9/12/11. The turtle measured 88.5cm (CCL) and 83.5cm (CCW) and was flipper tagged for the first time. A DNA sample was also taken.

Flipper damage was extensive with the tip missing from the right front, half of the right rear flipper absent and the entire left rear flipper missing. The damage resulted in the turtle not being able to dig a body pit and 12 attempts were made at digging a nest chamber. After lengthy observations, the nesting activity was recorded as a false crawl with the turtle observed still on the beach the next morning at sunrise. Disorientated and exhausted she eventually returned to the water and was not sighted again during the program.

4. References

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Appendices

Appendix 1 Summary of results

2011 nesting activity for flatback turtles *(Natator depressus)* at Eco Beach, Western Australia

Total distance of the survey area		***12km***
Total number of records (nests and false crawls)		***202***
Number of nests		***67***
Number of false crawls		***135***
Nesting activity by other species		***1***
Number of turtles tagged during the program		***14***
Number of remigrant females from other programs		***0***
Number of remigrant females from previous years		***7 from 2008 6 from 2009 2 from 2010***
Number of individual turtles seen		***29***
Interclutch interval (number of nights)		***11***
Number of turtles observed successfully nesting more than once		***6***
Average carapace length (CCL):		***88.3cm***
	Maximum	***95cm***
	Minimum	***84cm***
Average carapace width (CCW):		***73.8cm***
	Maximum	***80cm***
	Minimum	***70cm***
Average track width:		***97.3cm***
	Maximum	***116cm***
	Minimum	***70cm***
Average number of body pits per turtle:		***1.5***
	Maximum	***12***
	Minimum	***0***
Average number of eggs per nest		***46***
Average nest depth		***41cm***
Location of nests by sector:	*Resort*	***34***
	Cliffs	***11***
	Jack's Creek	***22***
Location of false crawls by sector:	*Resort*	***47***
	Cliffs	***13***
	Jack's Creek	***75***
Number of predated nests		***9***
Number of predated nests by sector:	*Resort*	***5***
	Cliffs	***0***
	Jack's Creek	***4***
Average hatch success rate of exhumed nests		***83%***
Favoured moon phase for nesting activity		***New Moon***
Main nesting periods		***15th to 18th Nov 26th to 30th Nov***
Lowest temperature recorded by a nest data logger		***25.89ºC***
*Highest temperature recorded by a nest data logger * 54.66 from an eroded nest*		***36.62 ºC ****
Number of Platform Terminal Transmitters deployed		***4***

Appendix 2 Further acknowledgements, supporters and sponsors

 Western Australia Department of Environment and Conservation

The input, technical comments and general support of this program by Dr RIT (Bob) Prince is appreciated.

 Wildlife Computers (USA)

Representatives, including Kevin Lay, provided invaluable assistance and advice on Platform Terminal Transmitter programming and data analysis of the preliminary results.

 Woodside Energy

The four PTTs deployed at Eco Beach during 2011 were donated by Woodside Energy. We gratefully acknowledge this donation in addition to the Woodside and Conservation Volunteers Australia Coastal Guardians Program.

 Canon Australia

As a category winner in the 2011 Canon Australia Environmental Grants, Conservation Volunteers Australia received for our Eco Beach program high powered binoculars and accessories to help monitor an adjoining potential nesting beach.

 Crackpots Marine & Rural Supplies

The harnesses used for the platform terminal transmitters were mostly hand made especially for Australian flatback sea turtles. Years of research and development have gone into their design.

 CLS (Collecte Localisation Satellites) & www.seaturtle.org

CLS – Argos Systems is the satellite telemetry used to receive signals from the transmitters. The raw data is received by CLS and then processed by the free STAT software and system operated by seaturtle.org.

 Wild Futures partners, supporters and donors

The science-based field work undertaken by Conservation Volunteers Australia researchers and volunteers is supported by our Wild Futures program which works to protect key species and their habitats. We gratefully acknowledge the following additional Wild Futures sea turtle supporters:

- Caltex Australia
- Cooper Industries

Appendix 3 Volunteer and staff contribution

A program such as this can only operate in the field with the support and enthusiasm of the many volunteers who travelled far and logged the required hours patrolling the beach at night. Volunteers learnt many new skills including nest versus false crawl determination, assisting with flipper tagging and DNA sampling, measuring and inspecting the turtles, conducting egg counts, GPS usage, PTT deployments, predator identification, nest exhumations and conducting the morning surveys.

The author would like to thank all volunteers who added to the enthusiasm, fun and science of this program; whether surviving the sometimes harsh winds camping the night up at Jack's Creek, or restraining a turtle for tagging on her way back to the sea.

The level of interest in the program continued to increase during 2011 from a number of sources:

- International and Australian volunteers from Biosphere Expeditions booked out the first two weeks of the program and CVA extend our thanks to participants and staff.
- An enthusiastic bus full of Year 5 students from St Mary's College Broome attended the program for a day of local environmental and sea turtle learning. The trip was part of their prize for the best representative banner produced during Conservation Week.
- Students from Roebuck Primary School, Derby District High School (photo below) and Fitzroy Valley High made the trip to Eco Beach to patrol at night and get up close and personal with nesting flatbacks.
- Guests and staff of the resort also joined night patrols when space allowed and all showed great support of the program.
- Personnel from the University of Western Australia & CSIRO Marine and Atmospheric Research in Perth also attended. PhD Candidate Julia Reisser worked as a Research Assistant during the tagging component of the program and then returned with senior representatives during the hatchling component to conduct acoustic tracking of hatchlings.

Covering the tagging and hatchling components of the program, a total of 162 staff days and 309 volunteer days took place in the field. This equates to 2,355 hours on the beach over 80 days.

Special thanks to the CVA Marine Species Research Assistants who participated and helped make the program a success, especially Corinne Chambers as Coordinator. Joining Corinne and the author in 2011 were Kerry Hadley, Anne Mueller, Julia Reisser, Alan Sumnall, Tony Dingwall, Damon Pages-Oliver and Simon Rosengarten.

The Eco Beach Sea Turtle Monitoring Program cannot occur without strong behind the scenes support. We appreciate and acknowledge the efforts of the CVA Broome staff in coordinating volunteers to and from the project and keeping us rolling in jelly snakes to eat during patrol breaks at night. The team of CVA's Naturewise personnel at National Office, led by Jo Davies, handled volunteer bookings and liaison with Jodie, Josie and additional staff at Eco Beach Resort.