Appendix F27

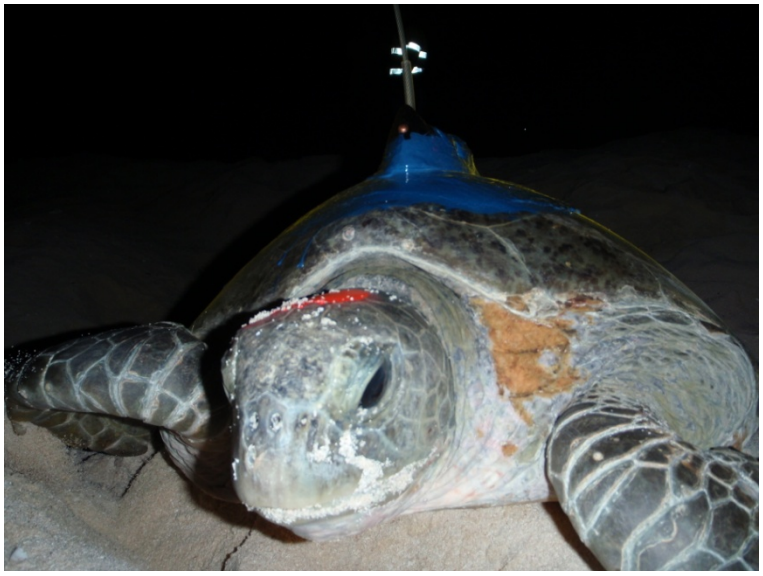
Guinea 2011

Long Term Monitoring of the Marine Turtles of Scott Reef
Satellite Tracking of Green Turtles from Scott Reef #1

BROWSE FLNG DEVELOPMENT
Draft Environmental Impact Statement

EPBC 2013/7079
November 2014

Browse LNG Development



SCOTT REEF GREEN TURTLE SATELLITE TRACKING REPORT #1

- Rev 3
- 04 April 2011

Browse LNG Development

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- Rev 3
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Sinclair Knight Merz
ABN 37 001 024 095
11th Floor, Durack Centre
263 Adelaide Terrace
PO Box H615
Perth WA 6001 Australia
Tel: +61 8 9469 4400
Fax: +61 8 9469 4488
Web: www.skmconsulting.com

Limitation Statement

The sole purpose of this report and the associated services performed by Sinclair Knight Merz ("SKM") as part of the Consolidated Environmental Services ("CES") contract is to report on the Scott Reef green turtle satellite tracking project in accordance with the scope of services set out in the contract between CES and the Client. That scope of services, as described in this report, was developed with the Client.

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Executive Summary

Woodside Energy Ltd (Woodside) is proposing to develop the Torosa, Brecknock and Calliance gas fields located approximately 270 km off the Kimberley coast in the Browse Basin. The Torosa field lies partly under Scott Reef, which is listed on the Register of the National Estate, with its heritage value detailed as providing, among other values, "breeding habitat for the nationally vulnerable green turtle (*Chelonia mydas*)."

Woodside requested that the Consolidated Environmental Services (CES) Partnership develop a long term marine turtle monitoring programme for nesting marine turtles at Sandy Islet, Scott Reef, including satellite tracking. The aim of the satellite tracking programme was to study inter-nesting and post nesting movements of green turtles nesting on Sandy Islet. This information will be used in the assessment of potential environmental impacts on the nesting marine turtle population from the Browse LNG Development activities at Scott Reef and informing subsequent management arrangements.

A total of twelve satellite tags were attached to green turtles after nesting on Sandy Islet, Scott Reef. This report presents the findings from the satellite transmissions from these turtles for the period of January 2010 to 30 December 2010 however no location data was received after 17 June 2010. **Table 1-1** presents a summary of the satellite tags deployed at Scott Reef.

- **Table 1-1: Summary of satellite data of the 12 green turtles that were satellite tracked following nesting at Sandy Islet, Scott Reef.**

Turtle ID	Date Released	Last Transmission used in data analysis	Days at Large	Foraging Ground Reached (Y/N)	Max Migration (km)
SN49666	6/02/2010	6/04/2010	59	NA	497
SN49669	1/02/2010	18/05/2010	106	NA	1574
SN49675	31/01/2010	26/04/2010	85	Y*	1141
SN49676	3/02/2010	16/05/2010	102	Y*	898
SN49683	30/01/2010	07/04/2010	67	NA	NA
SN49686	2/02/2010	20/03/2010	46	NA	700
SN50060	3/02/2010	17/06/2010	134	Y*	570
SN50062	4/02/2010	25/03/2010	49	NA	850
SN50065	2/02/2010	29/04/2010	86	Y*	1321
SN50066	6/02/2010	27/03/2010	49	NA	NA
SN50070	2/02/2010	12/05/2010	99	Y*	512
SN50075	29/01/2010	24/03/2010	54	NA	625

NA - satellite stopped transmitting prior to turtles reaching foraging grounds

*detailed foraging movements illustrated in Appendix A

Inter-nesting habitats were located within Scott Reef and ranged from the reef edge at Sandy Islet, to the southern reef 14 km to the south of the island. The satellite tracking programme data indicated that the average re-nesting interval was 10 days and the maximum number of clutches per nesting female was five (acknowledging that females may have laid additional nests prior to the application of transmitters).

Turtles were found to migrate from Sandy Islet to the mainland by either travelling north-east to the Bonaparte Archipelago and then following the coast to the Northern Territory, or south to Cape Leveque and along the coast to the mouth of the De Grey River in the Pilbara. Five turtles were determined to have reached their foraging grounds. These areas ranged from Eighty Mile Beach and into the Gulf of Carpentaria at Blue Mud Bay.

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SKM

Document history and status

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	Name	Signature	Date
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Project Director	C Bullock	C Bullock	04/04/2011

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Rev A		30/07/10	C Bullock	Technical/Project Director	C Bullock
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1. Introduction

Woodside Energy Ltd (Woodside) is proposing to develop the Torosa, Brecknock and Calliance gas fields located approximately 270 km off the Kimberley coast in the Browse Basin. While Brecknock and Calliance are located in deep water (400 m to 700 m), the Torosa field lies partly under Scott Reef. Scott Reef consists of two emergent shelf atolls, called North Reef and South Reef which occur on the edge of Australia's North West Shelf. Within the South Reef lagoon there is a mobile sand cay, Sandy Islet, which is a green turtle nesting beach. Scott Reef is listed on the Register of the National Estate, with its heritage value detailed as providing, among other values, 'breeding habitat for the nationally vulnerable green turtle (*Chelonia mydas*)'. Under the *Environment Protection and Biodiversity Conservation Act*, green turtles are listed as 'migratory, marine' species and are considered 'Vulnerable'. Under the Western Australian Wildlife Conservation (Specially Protected Fauna) Notice 2008, green turtles are considered 'Rare or Likely to Become Extinct'.

Recent advances in technology have provided the opportunity to use satellite transmitters and temperature depth recorders (TDR) to obtain precise location data and detailed diving behaviour of wide-ranging marine vertebrates including marine turtles (Fedak et al. 2001, Hays 2008). These methods have been used to determine the movement and habitat usage of green turtles, however there is only limited information available for Western Australian breeding stocks. Specific details relating to migration routes, foraging grounds, dive duration, frequency, and exact dive depth remains unknown, particularly for Scott Reef nesting turtles.

1.1. Objectives

Woodside engaged the CES Partnership with Charles Darwin University (CDU), to develop and undertake the 'Scott Reef Long Term Marine Turtle Monitoring Field Programme'. The objective of the programme was to:

- investigate inter-nesting turtle behaviour and habitat usage within Scott Reef; and
- establish a baseline dataset of biological data for nesting marine turtles in order to define and monitor the size, philopatry, reproductive periodicity, reproductive success, genetics and biometrics of the population.

The aim of the satellite tracking component of the overall monitoring programme was to address inter-nesting behaviour and habitat usage within Scott Reef and to provide data on post nesting movements of green turtles nesting on Sandy Islet. This information will be used in the assessment of potential environmental impacts on the nesting marine turtle population from the Browse LNG Development activities at Scott Reef and informing subsequent management arrangements. This report presents the results from the satellite tracking programme from January 2010 to 30 December 2010.

2. Methods

A brief summary of the methods employed for the satellite tracking component of the overall monitoring program are provided in the following sections. A detailed description of the methods can be found in Guinea (2010b).

2.1. Field Methods

Satellite transmitters (6 Sirtrack transmitters and 6 St Andrews Sea Mammal Research Unit (SMRU) transmitters) were attached to 12 green turtles post-nesting at Sandy Islet. The procedures followed the general guidelines for attaching satellite tags (Mitchell 1998, Coyne et al. 2008).

2.2. Data Processing

All satellite transmitters produced two types of data; ARGOS LC data and Fastloc GPS data. The SMRU satellite transmitters also recorded and transmitted dive data.

The Fastloc data was downloaded from the Argos satellite system and processed using a specially developed SirTrack/SMRU software program. The data was then filtered to remove inaccurate location points. The filter removed locations on land (based on the GeoScience Australia Coastline 100k), speeds greater than 5 km/h, locations with turning angle greater than 70 or turning angle less than -70, and locations with step length greater than 150 km. Filtering for the SMRU data was automated within the software program and locations were eliminated based on speeds over 5 km/h and residuals greater than 100.

The following definitions were used during data processing:

- Nesting attempt – where a fix was located on Sandy Islet.
- Successful nesting attempt – where a fix was located on Sandy Islet and was not recorded on Sandy Islet for the following seven days. If the renesting interval was more than 12 days (based on 12 days renesting interval for green turtles in the northern Great Barrier Reef; Limpus 2007) fixes within 200m were examined and the last recorded fix within 200m was used as the nesting date.
- Nesting interval – time in days from one successful nesting attempt to the next nesting attempt (whether successful or not) (Whiting et al. 2007).
- Migration starting point – the first day of movement away from Scott Reef after the last successful nesting.
- Migration end point – when the tracks began to traverse within a defined area for an extended period of time.

The SMRU units provide data on the duration that turtles are out of the water, haul-out data, which was used to confirm nesting attempts as defined below:

- Nesting attempt – where a fix was located on Sandy Islet which coincided with a haul out event.
- Successful nesting attempt – where a fix was located on Sandy Islet which coincided with a haul out event and was not recorded on Sandy Islet for the following seven days.

The SMRU satellite transmitters also recorded and transmitted a summary of dive data (including maximum depth, average dive depth, average dive duration, % surface time, % dive time and % haul out/out of water time) over 6 hour blocks. While data on individual dives are available, there are limits on the number of dives uploaded to the satellite (due the limitations in the satellite link i.e. time and size of data) therefore the summary provides a more robust dataset. There are limitations to the summary data as well, as only a proportion of the recorded 6 hour blocks are transmitted. Subsequently there will be missing data for both entire days as well as blocks of days.

Only Fastloc data was used in the speed and distance calculations, as it has a higher level of accuracy (± 100m) compared to ARGOS LC data. The ARGOS data is assigned location classes (LC) based on an estimate of accuracy. These classes were:

- LC3 ± 250 m;
- LC2 ± 500 m;
- LC1 ± 1500 m;
- LC0 > 1500 m; and
- LCA & LCB – location accuracy cannot be estimated.

When Fastloc data was not available the ARGOS LC data was used to present migration routes. The data was then filtered to remove inaccurate location points. Data sets of ARGOS data were generated using a data filter that removed location classes A and B , speeds > 5 km/h and locations on land (based on the GeoScience Australia Coastline 100k) for SN49683 and SN50062, SN50065.

3. Results

3.1. Transmitters

The twelve transmitters remained active for between 49 days to over 135 days (mean 78; **Table 3-1**). While a number of tags were still active subsequent to the 'last transmission used in data analysis' (**Table 3-1**), these recorded locations were removed from analysis as they were deemed inaccurate according to the data filters applied prior to the statistical analysis.

Data was downloaded on 30 December 2010 and all available data was then post-processed for Fastloc data. The SMRU tags records and stores data that it collected in an internal buffer, which means that it can transmit data up to 3 months after the event. The intention of this is to smooth out variations in the opportunity to transmit data, caused by weather conditions or turtle behaviour. The satellite transmitter therefore gradually fills in the data over several weeks and will continue to upload data to the satellites for approximately 3 months after the event.

One transmitter, SN49683, was active but the data could not be used post-processing due to an unknown error. A solution could not be found through the manufacturer Sirtrack, and therefore ARGOS LC data was used. However, after applying the standard filter no data was available until the turtle had begun its migration, therefore the data was only used to display the migration route and was not used in any speed or distance calculations. Additionally Fastloc GPS data for SN50062 and SN50065 stopped being transmitted therefore ARGOS LC data was used in the analysis of the migration and foraging behaviour (**Table 3-1**).

- **Table 3-1: Processed Fastloc and ARGOS LC transmission information of the 12 green turtles that were satellite tracked following nesting at Sandy Islet, Scott Reef.**

Turtle ID	Date Released	Last Transmission used in data analysis	Days at Large	# Fixes (Fastloc)	# Fixes (LC0-3)	Type of Satellite Tag
SN49666	6/02/2010	06/04/2010	59	163	-	Sirtrack
SN49669	1/02/2010	18/05/2010	106	263	-	Sirtrack
SN49675	31/01/2010	26/04/2010	85	261	-	Sirtrack
SN49676	3/02/2010	16/05/2010	102	228	-	Sirtrack
SN49683	30/01/2010	07/04/2010	67	-	22	Sirtrack
SN49686	2/02/2010	20/03/2010	46	167	-	Sirtrack
SN50060	3/02/2010	17/06/2010	134	217	-	SMRU
SN50062	4/02/2010	25/03/2010	49	-	45	SMRU
SN50065	2/02/2010	29/04/2010	86	-	70	SMRU
SN50066	6/02/2010	27/03/2010	49	110	-	SMRU
SN50070	2/02/2010	12/05/2010	99	162	-	SMRU
SN50075	29/01/2010	24/03/2010	54	65	-	SMRU
Mean (Standard Error)			**78 (8)**	**182 (19)**	**46 (7)**	

3.2. Inter-nesting

Ten of the twelve turtles, returned to re-nest at Sandy Islet during the transmission period. Of the eleven turtles, one turtle returned to re-nest once and three turtles returned to re-nest four times. The remainder of the turtles re-nested either two or three times (**Table 3-2**). Based on the satellite data the maximum clutches per season per female was at least five. Inter-nesting intervals ranged from 8 to 22 days, with a mean of 10 days (**Table 3-2).** During the inter-nesting period turtles remained within 3 km of Sandy Islet, with the exception of two turtles who travelled into South Scott Reef Lagoon, over 14 km south (**Table 3-2; Figure 3-2).** The majority of the location fixes were within an area south of Sandy Islet, where the water depth ranged from 5 to 10 m. However, the mean recorded maximum water depth was 35.3 m, which is attributed to the marked changed in bathymetry within 1 km of Sandy Islet where water depths drop in excess of 40 m. This data was supported by the SMRU tags which also recorded dive depths. The average dive depths were recorded in 6 hour blocks and ranged from 1 m to 24 m, while the average dive depths (based on the average of 6 hour blocks) ranged from 5.8 m to 9.6 m. The maximum dive depth ranged from 35 to 45 m.

A previous document (Guinea 2010a) reported on the movements of the twelve satellite tagged green turtles from deployment in January/February 2010 to 31 March 2010. Only two nesting

turtles (SN50060 and SN50070) remained at Scott Reef after March 31st 2010 and their inter-nesting locations are illustrated in **Figure 3-1** and **Figure 3-2.** For the inter-nesting movements of the other turtles, refer to Guinea (2010a).

During the inter-nesting period turtles spent the majority of their time in dives which accounted for 83.2% of their activities, while 15.2% was spent at the surface and only 1.6% was spent on the Sandy Islet. On average dive duration ranged from 15 to 25 minutes, and the maximum dive duration was 55 minutes (**Table 3-3**).

One turtle (SN50066) stopped transmitting during the inter-nesting period while at Scott Reef (March 2010).

- **Table 3-2: Inter-nesting intervals of green turtles from Sandy Islet, including the maximum distance turtles moved away from the nesting beach during this period.**

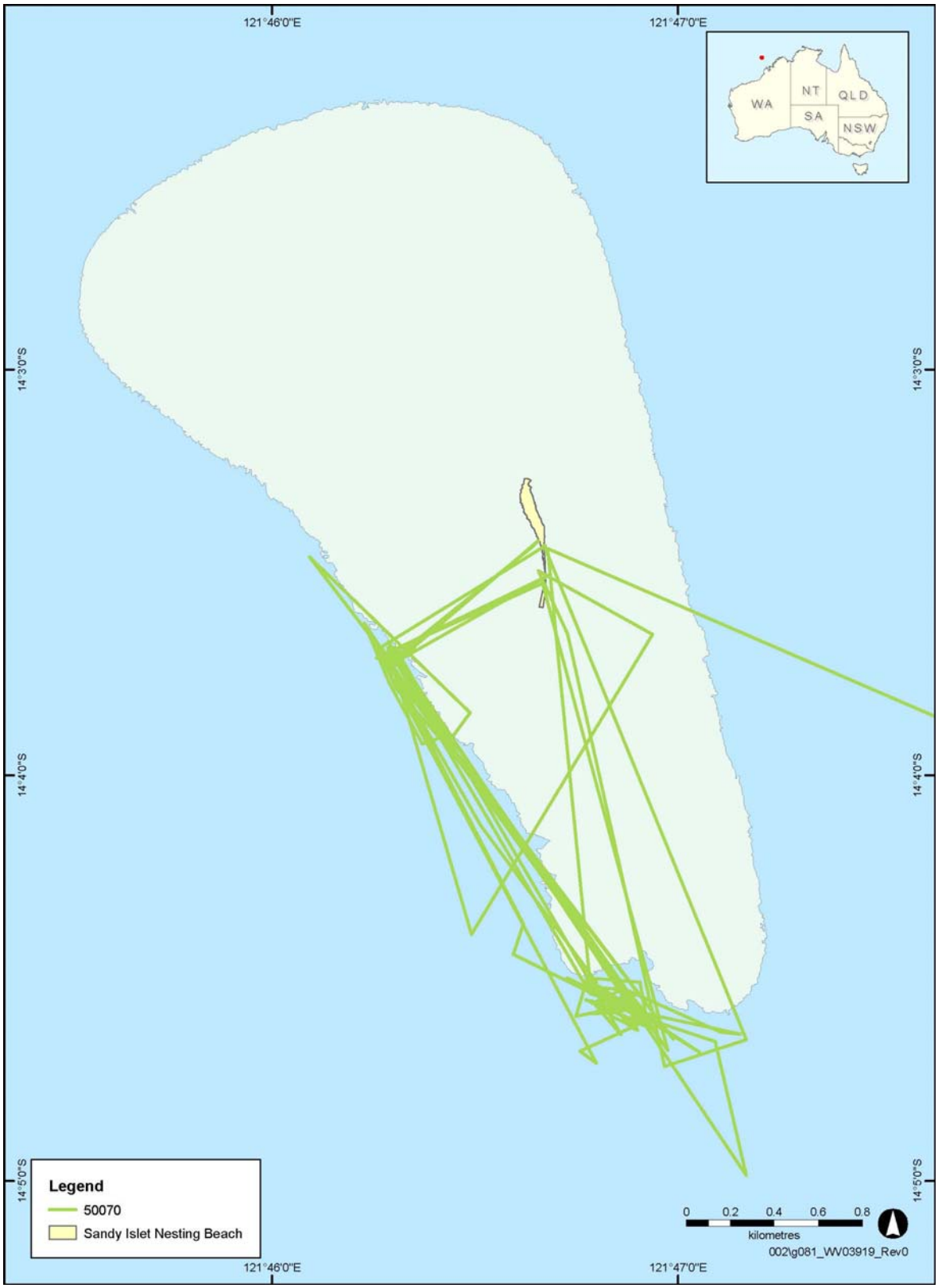
Turtle ID	Date of Nesting[1]	Date Returned[2]	Re-nesting Interval (days)	Max km from beach	Max Water Depth (m)
49666	10/02/2010 22/02/2010 08/03/2010 18/03/2010	19/02/2010 03/03/2010 17/03/2010	9 9 9	2.0	39
49675	31/01/2010 10/02/2010 20/02/2010 28/02/2010	09/02/2010 20/02/2010 28/02/2010	9 10 8	3.0	43
49676	04/02/2010 15/02/2010 26/02/2010	13/02/2010 23/02/2010	9 8	2.7	37
49686	01/02/2010 12/02/2010 23/02/2010	11/02/2010 23/02/2010	10 11	13.6	56
50060	02/02/2010 16/02/2010 11/03/2010 24/03/2010 05/04/2010	12/02/2010 10/03/2010 22/03/2010 03/04/2010	10 22 11 10	13.7	43
50062	03/02/2010 13/02/2010 23/02/2010	12/02/2010 23/02/2010	9 10	2.4	15
50065	01/02/2010 12/02/2010	10/02/2010	8	1.9	30
50066	05/02/2010 19/02/2010 04/03/2010 12/03/2010 24/03/2010	15/02/2010 28/02/2010 12/03/2010 23/03/2010	10 9 8 11	3.5	21
50070	13/02/2010 25/02/2010 10/03/2010 23/03/2010 3/04/2010	25/02/2010 08/03/2010 23/03/2010 3/04/2010	12 11 13 11	2.7	39
50075	29/01/2010 10/02/2010 24/02/2010	10/02/2010 24/02/2010	12 14	2.1	30
Mean (SE)			**10 (0.5)**	**4.8 (1.5)**	**35.3 (3.7)**

[1]Date of nesting is the nesting date

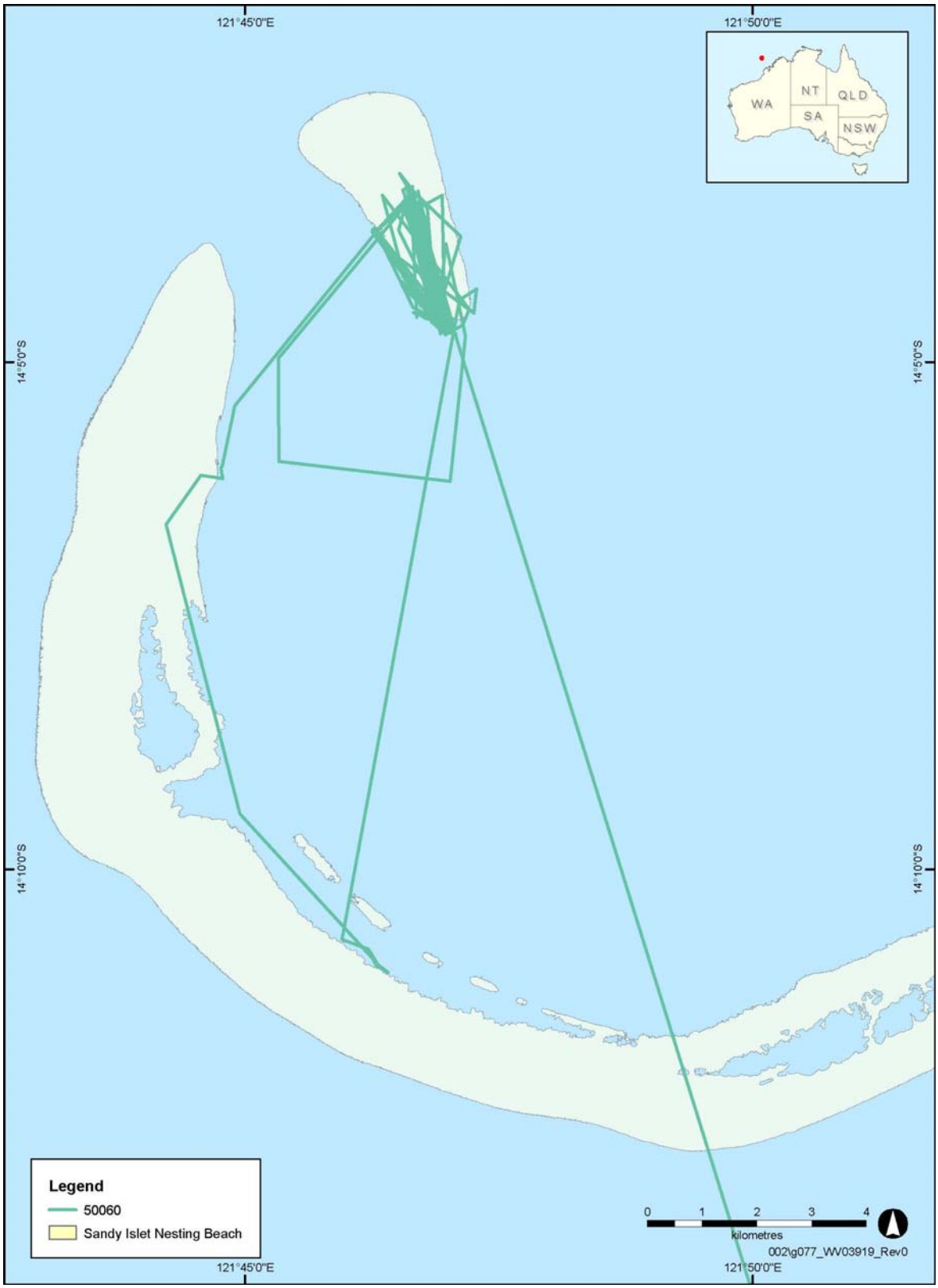
[2]Date returned is the first time after nesting that the turtle returned to Sandy Islet

- **Table 3-3: Dive characteristics of six inter-nesting green turtles at Scott Reef.**

Turtle ID	Depth of dives (over a 6 hour block)		Max depth	Dive durations (over a 6 hour block)		% dive time	% surface time	% haul out time
	Range of depths	Average depth of dives		Range of dive durations	Average duration			
50060	1-22	8.5	40	00:00:20 – 00:55:00	00:24:08	84.4	14.2	1.4
50062	1-14	6.1	40	00:00:36 - 00:45:00	00:23:57	84.2	14.7	1.1
50065	1-24	5.8	35	00:00:27 – 00:30:00	00:15:16	80.8	16.7	2.5
50066	2-20	6.6	45	00:00:57 – 00:45:00	00:18:42	82.3	15.4	2.3
50070	1-20	7.3	40	00:00:40 - 00:45:00	00:35:26	81.2	15.9	2.9
50075	4-24	9.6	35	00:05:00 – 00:40:00	00:19:46	87.2	11.3	1.5
Mean	**-**	**-**	**39**	**-**	**-**	**83.2**	**15.3**	**1.6**



- **Figure 3-1: Inter-nesting movements of a green turtle (SN50070) tracked from Sandy Islet, Scott Reef (using Fastloc data).**



- **Figure 3-2: Inter-nesting movements of a green turtle (SN50060) tracked from Sandy Islet, Scott Reef (using Fastloc data).**

3.3. Migration and Foraging

All of the turtles, except one (the satellite transmitter of SN50066 stopped while the turtle was at Scott Reef), migrated from Scott Reef. Following their final nesting, turtles quickly departed Scott Reef and followed one of two routes: one to the south and one to the north-east. The majority of the turtles (n=8) followed the north-east passage to the Bonaparte Archipelago on the Kimberley coast (**Figure 3-4**). There was a preference for swimming close to the coast, although SN50062 preferred to remain some distance from the coast but still moved towards the east. One turtle (SN50070) did not travel past Cape Bougainville and location data continued to be received from the area. The satellite tag SN49666 stopped transmitting during the migration period near Cape Bougainville.

Six tracks continued past Cape Bougainville, with five tracks extending into the Joseph Bonaparte Gulf and crossing into Northern Territory waters, reaching the Australian mainland coast between Docherty Island near Port Keats and Bathurst Island. The path of SN49676 did not continue past this point as of 23 March 2010, and then remained within the vicinity Fog Bay until 16 May 2010, when the satellite tag stopped transmitting. The paths of the other five continued along the chain of islands and reefs past Grose Island and either through Beagle Gulf or around Bathurst and Melville Islands to the Cobourg Peninsula. The satellite tags of both SN49863 and SN50062 stopped transmitting while transiting through the vicinity of Cobourg Peninsula. SN49675 remained within the area for three weeks before the satellite tag stopped functioning on 26 April 2010. Two turtles continued their eastward migration with SN49669 reaching Wessel Island before transmission stopped and SN50065 reached Blue Mud Bay in the Gulf of Carpentaria on 11 April 2010, location fixes continued to be transmit from within the area until 15 May 2010.

Three individuals moved south to the Kimberley coast near the Lacepede Islands and Cape Leveque (**Figure 3-3**). One individual (SN49686) remained close to the coast while the others (SN50075 and SN50060) may have been similar but was not recorded. All turtles passed into the Eighty Mile Beach area, where one (SN50060) remained feeding and another stopped transmitting (SN50075). The third turtle (SN49686) continued passed Eighty Mile Beach, almost reaching the mouth of the De Grey River in the Pilbara before transmission stopped.

For detailed movements of turtles assumed to have reached their foraging grounds see **Appendix A**.

Migration distances ranged from 497 km to 1574 km (based on Fastloc GPS data only), however four of the satellite tags stopped transmitting prior to the turtles reaching their foraging grounds (**Table 3-4**). Fastloc GPS data for two turtles stopped transmitting while Argos data continued to be transmitted for a number of additional months, however due to the accuracy limitations the data was not used in any calculations. One of those turtles, SN50065, travelled over 2000 km into Blue Mud Bay in the Gulf of Carpentaria based on the Argos LC data.

Average migration time was 31 ± 6 days (n=11). However, if data is excluded from the satellite transmitters that stopped during the migration route, the mean is 29 ± 8 days (n=5). On average,

turtles travelled 2.05 ± 0.12 km/hr. SN49666 had the highest average of 2.63 km/hr and the shortest migration displacement (**Table 3-4**).

During the migration period turtles spent the majority of their time in dives (73%), while the remainder of their time was spent at the surface. SN50062 did spend some time out of the water. This is assumed to be basking time as it was during the middle of the day and lasted 37 minutes (**Table 3-5**). Dive time during migration was similar to that recorded during foraging periods where turtles spent 70% of the time in dives and 30% at the surface (**Table 3-6**).

- **Table 3-4: Summary of migration and foraging ground characteristics of green turtles tracked following nesting at Sandy Islet.**

Turtle ID	Migration Days	Average Migration Speed (km/h)	Days in Foraging Grounds	Max Migration(km)
49666	12	2.63 (0.16)	NA	497
49669	66	1.82 (0.06)	NA	1574
49675	31	2.26 (0.09)	26	1141
49676	26	2.22 (0.11)	53	898
49686	24	2.08 (0.09)	NA	700
50060	13	2.02 (0.07)	59	570
50062	43	2.41 (0.12)	NA	850[1]
50065	56	2.03 (0.10)	18	1321[2]
50070	17	1.61 (0.09)	19	512
50075	26	1.38 (0.21)	NA	625
Mean	**31 (6)**	**2.05 (0.12)**	**35 (9)**	**869 (116)[3]**

[1]This only represents the data available from the fastloc GPS processing which stopped March 11 2010 however the Argos LC data continued for approximately another 455km.

[2] This only represents the data available from the fastloc GPS processing which stopped March 6 2010 however the Argos LC data continued for approximately another 1256km.

[3]The mean was calculated using Fastloc GPS data only

- **Table 3-5: Dive characteristics of four green turtles while migrating to their foraging grounds.**

Turtle ID	Depth of dives (over a 6 hour block)		Max depth	Dive durations (over a 6 hour block)		% dive time	% surface time	% haul out time
	Range of depths	Average depths		Range of dive durations	average duration			
50062	2-45	16.7	80	00:00:27 – 00:30:00	00:14:40	53	47	1
50065	3-40	9.9	45	00:00:51 – 00:35:00	00:10:44	75	25	0
50070	2-30	10.4	35	00:00:14 – 00:26:00	00:12:09	76	24	0
50075	14-20	16.7	35	00:00:06 – 00:30:00	00:14:00	89	11	0
Mean			**48.8**			**73**	**27**	**0**

- **Table 3-6: Dive characteristics of three green turtles while foraging.**

Turtle ID	Depth of dives (over a 6 hour block)		Max depth	Dive durations (over a 6 hour block)		% dive time	% surface time	% haul out time
	Range of depths	Average depths		Range of dive durations	average duration			
50060	3-18	10.8	20	00:00:12 - 01:00:00	00:26:35	87	13	0
50065	3-8	3.7	16	00:02:40 - 00:18:00	00:10:29	69	31	0
50070	3-10	5.0	20	00:02:00 – 00:35:00	00:12:26	53	47	0
Mean			**18.7**			**70**	**30**	

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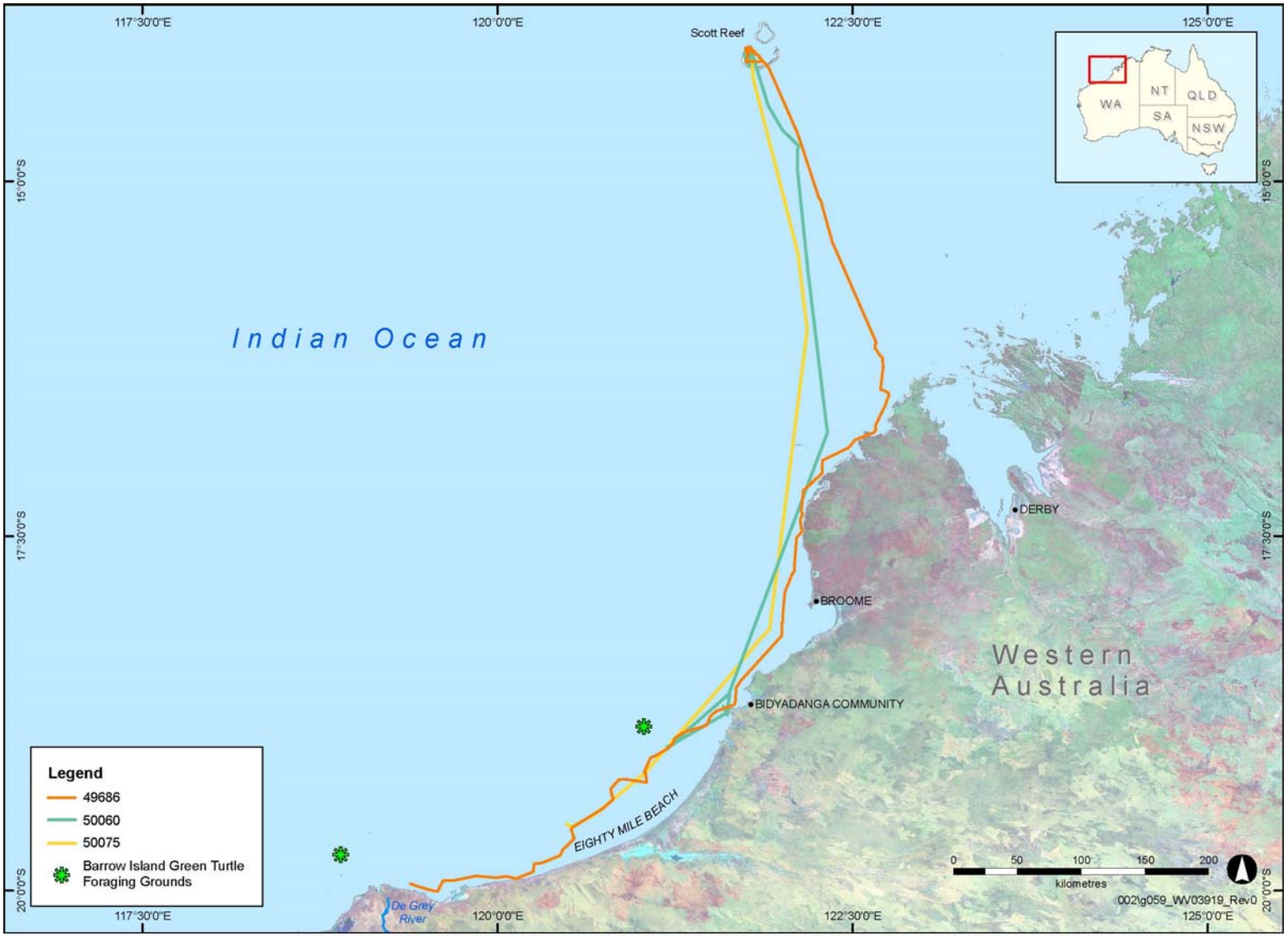
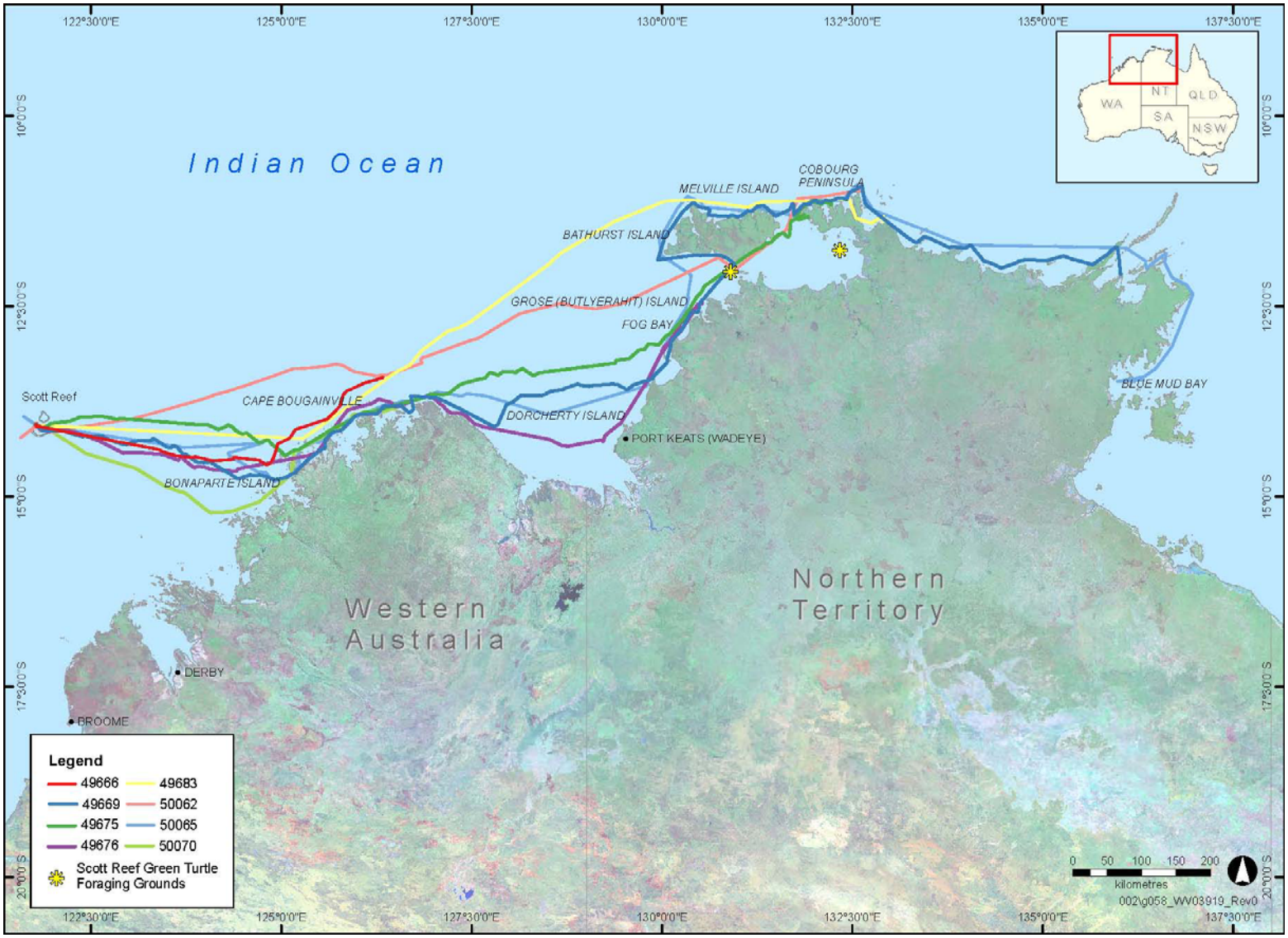


- **Figure 3-3: Migration routes south following nesting at Sandy Islet, Scott Reef (identified foraging locations from Pendoley 2005).**



- **Figure 3-4: Migration routes north-east following nesting at Sandy Islet, Scott Reef (identified foraging locations from Pendoley 2005).**

4. Discussion

4.1. Inter-nesting

Results for the satellite tagging of females at Sandy Islet indicated a preference for a few discrete aggregation areas mainly in the southern region of Sandy Islet reef, where water depths vary from 7 m to 17 m, and also directly west from Sandy Islet. The female turtles remained within 3 km of the nesting beach the majority of the time. However, two females moved to an expanse of shallow water and sand area within the southern part of Scott Reef, approximately 14km from Sandy Islet.

The average re-nesting interval for Sandy Islet nesting female turtles was 10 days. This is comparable with other studies of the re-nesting interval for green turtles. Limpus (2007) found that for the Southern Great Barrier Reef (GBR) stock the average re-nesting interval was 14.1±1.65 days. This was in contrast to the re-nesting interval for the Northern GBR stock which on average had a re-nesting interval of 12.4±1.02 days. The difference in the two GBR stocks is thought to be due to temperature as the length of the re-nesting interval will increase with cold water (Godley 2002). Based on the satellite data the maximum number of clutches laid per nesting female at Sandy Islet was five, this is similar to those determined at Bramble Cay, Queensland (6 clutches) and at Heron Island, Queensland (5 clutches) (Limpus 2007). However, it is possible that the number of clutches laid per nesting female could increase for females at Sandy Islet, as it was not known if any of the females had laid any clutches prior to attachment of the satellite tags.

4.2. Migration and Foraging

Migration

Eleven satellite tagged females migrated to the Australian mainland coast. One tag stopped transmitting while the turtle was still at Scott Reef. Three turtles travelled south towards Eighty Mile Beach. This is the first time Scott Reef turtles have been reported migrating to feeding grounds in the Pilbara. SN50060 remained at Eighty Mile Beach presumably feeding on seagrasses and algae.

Turtles migrating from Scott Reef had average speeds of 2.05 km/h. These speeds are similar to the migration speeds of previous green turtles from Scott Reef (Pendoley 2005) and to the migration speeds of other green turtle populations (Luschi et al. 1998, Balazs & Ellis 2000, Cheng 2000, Godley et al. 2002).

On average, the turtles that migrated south travelled 631 km. It must be noted that only one turtle were assumed to have reached foraging grounds, based on the definition provided in **Section 2.2**. This is in contrast to the turtles that migrated north-east that travelled up to 1574 km (one turtle travelled farther however Fastloc GPS data was not available for the full migration period) and averaged a migration distance of 924 km, with four of the turtles reaching their feeding grounds by the end of the monitoring period. The distances observed during the monitoring period for all

migrating turtles are consistent with the migration distances of other green turtle populations (Luschi et al. 1998, Balazs & Ellis 2000, Cheng 2000, Godley et al. 2002, Hays et al. 2002).

Foraging

Most of the turtles that migrated north-east were not recorded as stopping, although several satellite data points did congregate around the known green turtle feeding locations of Long Reef and Holothuria Reefs near Cape Bougainville. SN50070 did stop within the vicinity of Holothuria Reefs and Long Reef for 19 days and it is presumed to have reached its foraging grounds (based on the definition provided in **Section 2.2**).

Turtle tracks crossed to the Northern Territory reaching the Australian mainland coast between Docherty Island near Port Keats (another favoured green turtle feeding area) and Bathurst Island. SN49676 remained within the vicinity of Fog Bay foraging. The waters surrounding Bathurst Island and Melville Island are considered an important ecological feature and localised freshwater upwelling supports significant marine fauna feeding aggregations (DEWHA 2008). Turtle tracks continued along the chain of islands and reefs past Grose Island and into Beagle Gulf. The passage of these turtles through the reefs in the northern part of Fog Bay is reported locally as an annual occurrence. During March and April, adult green turtles pass through the shallow waters from Dum in Mirrie Island to Quail Island. This is the only time of year that large turtles are seen on this reef, which is a feeding ground for sub-adult greens and hawksbills (Maxwell Baumber personal communication 1996; Guinea personal observations 1996, 1997). The two turtles that passed through the Beagle Gulf were recorded as reaching their foraging grounds, one within the vicinity of Cobourg Peninsula, a known marine turtle feeding area, and the other to Blue Mud Bay in the Gulf of Carpentaria. The rocky reefs and sand flats of this part of the Northern Territory coastline support a number of seagrasses: *Thalassia hemprichii*, *Halodule uninervis*, *Halophila ovalis*, and *Enhalus acoroides*, macro algae including the seasonally abundant Sargassum spp. and *Cystoseir*a spp., *Turbinaria ornata*, *Padina australis* and turf algae with stands of *Laurencia* spp. and *Halimeda* spp.

Appendix A provides detailed movements of turtles assumed to have reached their foraging grounds.

5. References

Balazs GH, Ellis DM (2000) Satellite telemetry of migrant male and female green turtles breeding in the Hawaiian Islands 16th Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memo NMFS-SEFSC.

Cheng IJ (2000) Post-nesting migrations of green turtles (*Chelonia mydas*) at Wan-An Island, Penghu Archipelago, Taiwan. Marine Biology 137:747-754.

Coyne M, Godfrey M, Godley B, Lay K (2008) Hard Shell Sea Turtle PTT Attachment Protocol, http://www.seaturtle.org/documents/PTT_Attachment_Protocol.pdf (Accessed August 2009).

DEWHA (2008) The North Marine Bioregional Plan. Commonwealth of Australia.

Fedak MA, Lovell P, Grant SM (2001) Two approaches to compressing and interpreting time-depth information as collected by time-depth recorders and satellite-linked recorders. Marine Mammal Science 17:91-110.

Godley BJ, Richardson S, Broderick AC, Coyne MS, Glen F, Hays GC (2002) Long-term satellite telemetry of the movements and habitat utilisation by green turtles in the Mediterranean. Ecography 25:352-362.

Guinea M (2010a) Draft Long Term Monitoring of the Marine Turtles of Scott Reef: February 2010 Field Survey Report.

Guinea M (2010b) Long-term monitoring of nesting marine Turtles at Sandy Islet, Scott Reef: Methods Statement, Charles Darwin University, Darwin.

Hays GC (2008) Sea turtles: A review of some key recent discoveries and remaining questions. Journal of Experimental Marine Biology and Ecology 356:1-7.

Hays GC, Broderick AC, Godley BJ, Lovell P, Martin C, McConnell BJ, Richardson S (2002) Biphasal long-distance migration in green turtles. Animal Behaviour 64:895-898.

Limpus C (2007) A biological review of Australian Marine Turtles 2. Green Turtle *Chelonia mydas* (Linnaeus), Environmental Protection Agency Queensland.

Luschi P, Hays GC, Del Seppia C, Marsh R, Papi F (1998) The navigational feats of green sea turtles migrating from Ascension Island investigated by satellite telemetry. Proc R Soc Lond B 265:2279-2284.

Mitchell SV (1998) Loggerhead Sea Turtle (*Caretta caretta*) Satellite Tagging Project 18th Annual Sea Turtle Symposiums, http://www.graysreef.nos.noaa.gov/smitchellposter.html. (Accessed August 2009).

Pendoley K (2005) Sea Turtles and the Environmental Management of Industrial Activities in North West Western Australia Murdoch University.

Whiting S, Long JL, Coyne M (2007) Migration routes and foraging behaviour of olive ridley turtles *Lepidochelys olivacea* in northern Australia. Endangered Species Research 3:1-9

Appendix A Migration and foraging movements of green turtles

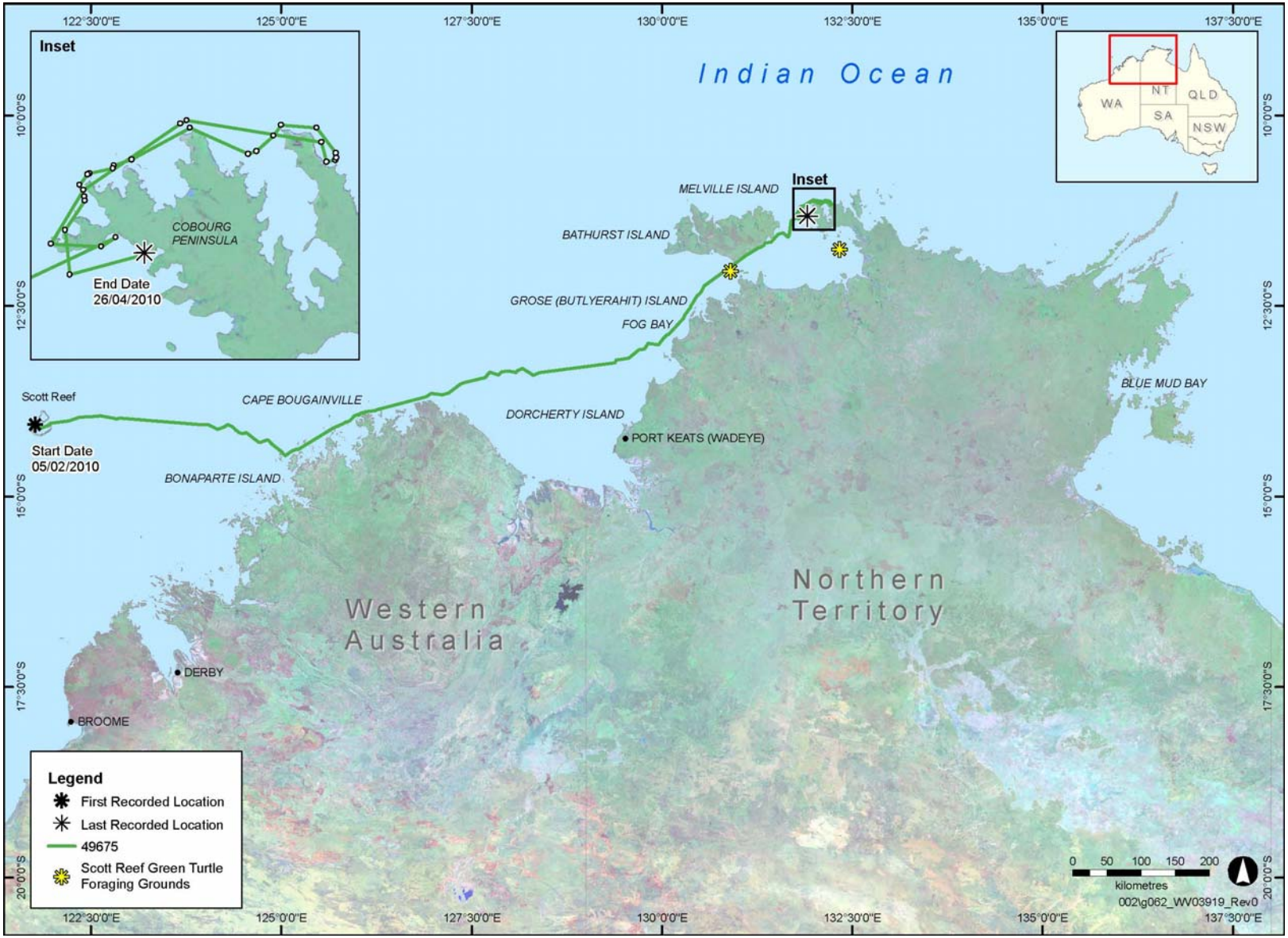
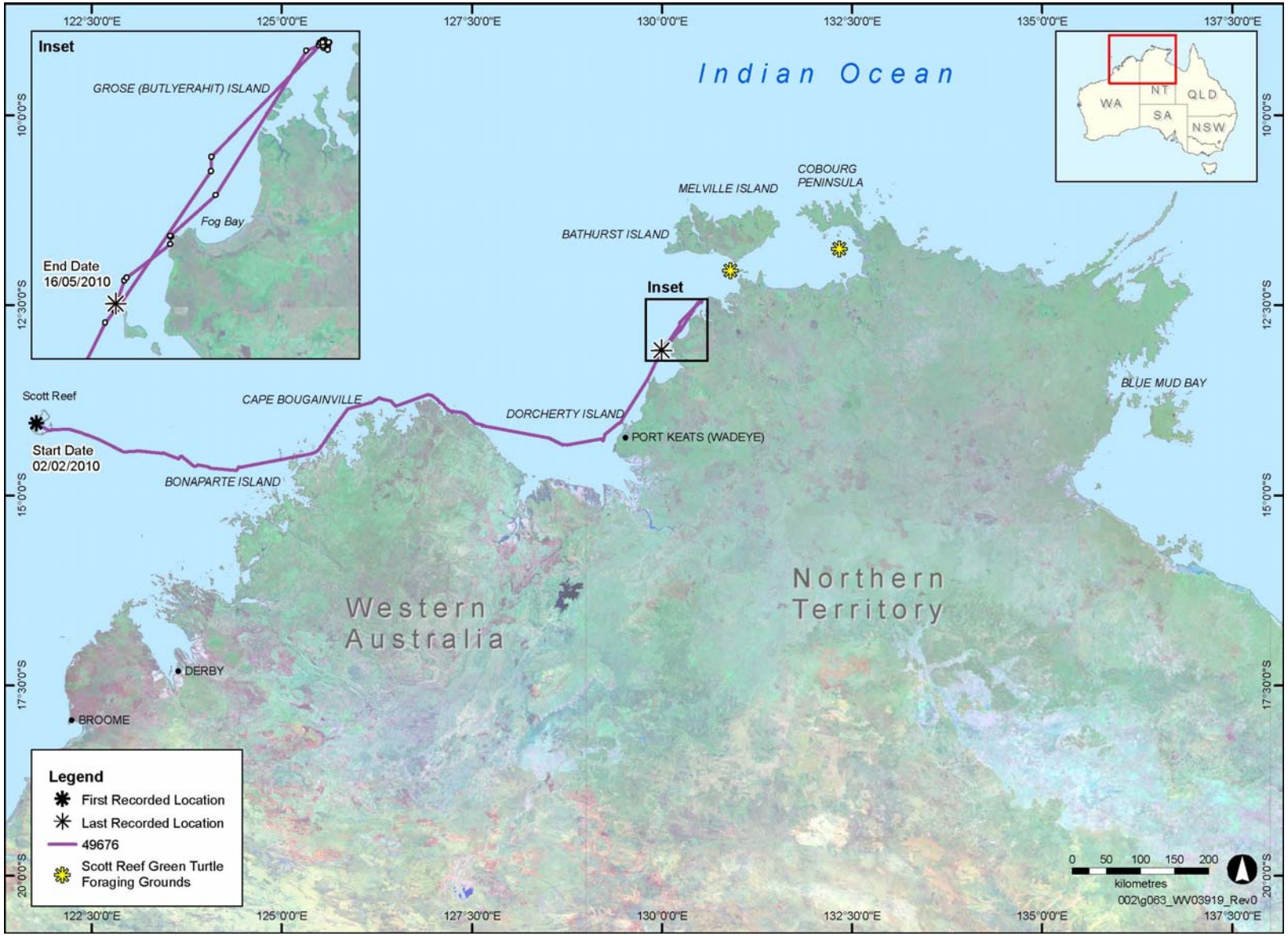
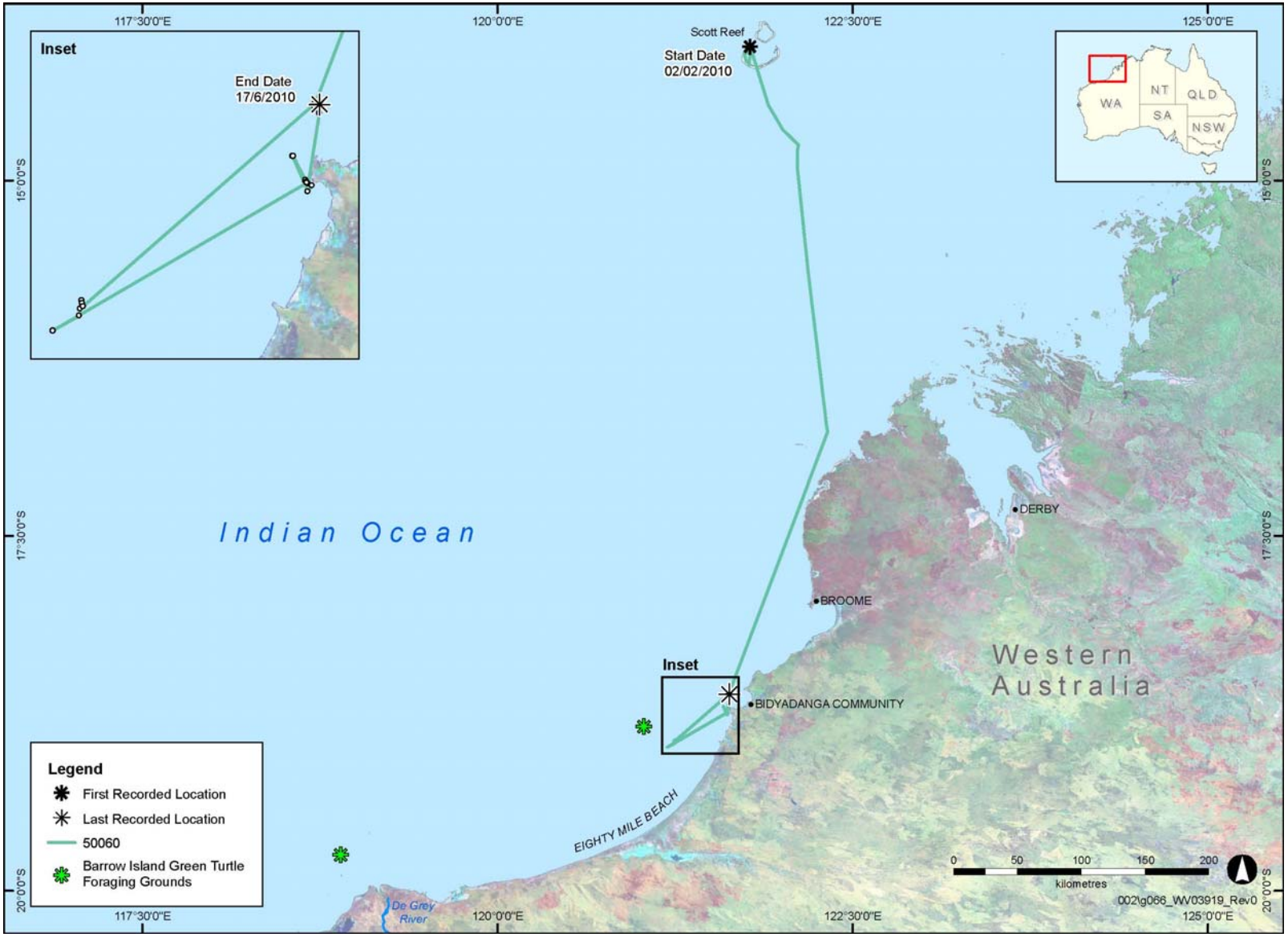


Figure A-1: Migration route of turtle SN49675 following nesting at Sandy Islet, Scott Reef; inset details the turtles foraging movements (Foraging locations from Pendoley 2005).

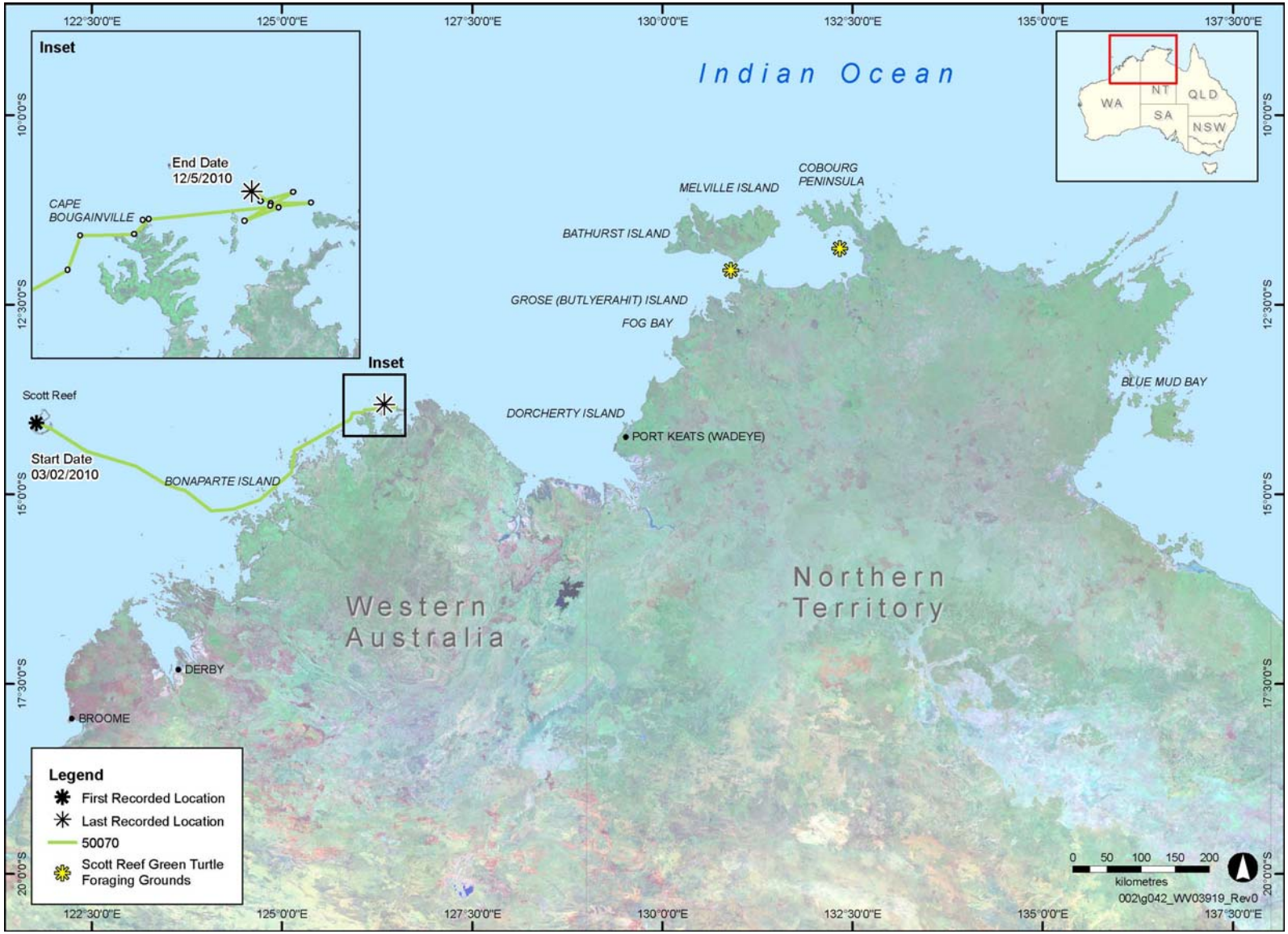


- **Figure A-2: Migration route of turtle SN49676 following nesting at Sandy Islet, Scott Reef; inset details the turtles foraging movements (Foraging locations from Pendoley 2005).**



- **Figure A-3: Migration route of turtle SN50060 following nesting at Sandy Islet, Scott Reef; inset details the turtles foraging movements (Foraging locations from Pendoley 2005).**

- **Figure A-4: Migration route of turtle SN50065 following nesting at Sandy Islet, Scott Reef; inset details the turtles foraging movements (Foraging locations from Pendoley 2005).**



- **Figure A-5: Migration route of turtle SN50070 following nesting at Sandy Islet, Scott Reef; inset details the turtles foraging movements (Foraging locations from Pendoley 2005).**