

**Survey of marine turtle nesting distribution in
Queensland, 2000 and 2001:
Broad Sound to Repulse Bay, Central Queensland**



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1. Introduction

The flatback turtle, *Natator depressus*, is a marine turtle endemic to the Australian continental shelf and all known nesting sites occur within Australia. Recent studies indicate that the flatback turtle breeding population of eastern Queensland is genetically distinct from that of northern Australia (FitzSimmons *et al.* 1996). The eastern Australian stock has a breeding distribution that extends from Bundaberg in the south to approximately Cairns in the north (Limpus *et al.* 2002a).

While numerous nesting sites are known for the species in eastern Australia (Limpus *et al.* 2002a), there still remain some uncertainties in the size of the nesting population at many sites. Surveys of marine turtle breeding in eastern Australia have been conducted intermittently since 1968 (Kowarsky 1978; Limpus 1980, 1985; Limpus and Preece, 1992; Limpus *et al.* 1981, 1983a,b, 1989, 2001, 2002a,b; Miller and Limpus 1991; Miller *et al.* 1995). Two aerial surveys in recent years have contributed to the definition of the extensive flatback turtle nesting in Torres Strait and the eastern Gulf of Carpentaria (Limpus and Miller, 2000). These surveys were flown in the summer of 1997 and the winter of 1999. Numerous on ground visits to islands and beaches as well as extensive aerial surveys of the east coast between Torres Strait and the Palm Islands have failed to identify anything beyond sporadic nesting by flatback turtles in this area that supports large concentrations of nesting green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles (Limpus 1985; Limpus and Miller, 2000). The southern part of the east coast flatback turtle nesting distribution on the mainland coast and continental islands from Baffle Creek to Stockyard Point was surveyed by air during the 1998 breeding season (Limpus and Miller, 2000).

As of 2000, the area with the poorest definition of marine turtle nesting in eastern Australia has been the flatback dominated nesting area from Rockhampton to Mackay. The present report describes the results of the aerial surveys of turtle nesting in the northern Shoalwater Bay to Repulse Bay area that were conducted in November 2000 and November 2001 and addresses a large part of this deficiency.

2. Methods

The methodology employed in the present study followed that of previous aerial surveys of marine turtle nesting conducted by Queensland Parks and Wildlife Service (Limpus and Miller, 2000).

To define the beaches, the coastline was subdivided into discrete lengths of sandy beach delimited by prominent features such as rivers, creeks, headlands and rock outcrops. Each beach was identified by the latitude and longitude at the commencement of the beach when travelling in a clockwise direction around the Australian coastline or around an island. For small islands with only a single beach, the latitude and longitude is taken from the mid point of the island. Latitudes and longitudes were read from the respective marine charts or from cadastral maps displayed via GIS software (Anon 1996).

2.1 Species identification from tracks:

When turtles were not sighted, tracks from nesting turtles were identified to species using the following key:

- 1a. breast-stroking gait (rear flipper marks on either side of the central skid mark of the plastron are adjacent) **go to 2**
- 1b. alternating gait (hind flipper marks on either side of the central skid mark of the plastron are not adjacent) **go to 4**

- 2a. narrow (<10cm wide) or no front flipper marks outside of the hind flipper marks
..... *Natator depressus*
- 2b. wide (>10cm wide) and obvious front flipper marks outside of the hind flipper marks
..... **go to 3**
- 3a. medium width track (<130cm wide) from outer edges of front flipper marks
..... *Chelonia mydas*
- 3b. very wide track (>150cm wide) from outer edges of front flipper marks
..... *Dermochelys coriacea*
- 4a. in eastern Australia, south of 16°S latitude..... *Caretta caretta*
In the absence of any records of *Eretmochelys imbricata* or *Lepidochelys olivacea* attempting to nest in the south and central Queensland in the past 30yr, all alternating gait tracks in this area are presumed to have been from *C. caretta*.
- 4b. in eastern and northern Australia, north of 16°S latitude
..... *Eretmochelys imbricata* or *Lepidochelys olivacea*
In the absence of any records of *Caretta caretta* attempting to nest in north Queensland or Arnhem Land, Northern Territory in the past 40yr (except for an unsuccessful nesting attempt recorded at Lizard Island in 1973 [Limpus, 1985]), all alternating gait tracks in this area are presumed to have been from either *E. imbricata* or *L. olivacea*.

2.2 Aerial survey

High-winged aircraft were selected for the surveys so as to maximise vision of the beaches from the aircraft. Flight dates were chosen to meet the following conditions:

- to occur within the period of highest nesting density for the species of greatest interest within the survey area, In central Queensland this was during the peak period of flatback turtle nesting in the last week of November and the first week of December.
- to coincide with an approximately midnight high tide on the night before the flight so as to provide the maximum beach width when the flight commenced early in the morning. It also provided approximately 6hr of flying before that day's high tide would wash out the tracks from the night before.

In addition, by flying early in the morning, the tracks were more visible than later in the day after the sun had dried the surface sand and the increasing onshore winds had blurred the tracks.

Turtle tracks from the night preceding the flight were counted for each species on each beach. A "track" up and a "track" down the beach were counted as a single track (= 1 turtle beaching) for these census studies. During the summer months on the Mackay coast the daytime high tide was higher than the night-time high tide. Therefore counting the turtle tracks which crossed the beach below the previous day's high tide mark provided a count of the number of turtle beachings for the previous night. Counts of older tracks which terminated at the previous day's high tide mark and counts of old body pits provided additional qualitative information on the level of nesting for the beach. During aerial surveys, no attempt was made to determine the nesting success for the individual beachings because much of the turtle nesting habitat was within the vegetated zones of some of the islands.

Based on examination of aerial photographs, a number of islands and rocks (Table 1) in the proposed survey area were determined to have a totally rocky shore line without beaches and therefore would not be turtle nesting sites. Based on prior knowledge of the area by Steve Fisher and from examination of marine charts, the coastline of southern Broad Sound from Coal Island (22.1418°S, 149.8677°E) in the east to the northern bank of Cattle Creek (22.1475°S, 149.5981°E) in the west was determined to be a mud and mangrove coastline with no sand beaches suitable for turtle nesting. These islands and the southern part of Broad Sound were excluded from close examination during the aerial survey and have been scored in the database as supporting no turtle nesting.

Table 1. Islands and rocks examined via aerial photographs and which were determined to have a total rocky shore without sand beaches.

Name of feature	GBRMPA island code
Roundish Island	22-010
Bluff Islet	21-331
Dinner Islet	21-339
Penn Islet	21-051
Renou Islet	21-037
Overfall Rock	-
Bailey Islet	21-026
Slade Islet	-
Elamang Island	21-046
Hinst Islet	21-325
Maryport Islet	20-266
Edgell Rock	-
Coffin Islet	20-261
Helvellyn Rocks	-
Hammer Island	20-246
Bellows Island	20-250
Locksmith Island	20-248

The aerial surveys were flown out of Mackay airport at 150-220km hr⁻¹ and at 25-60m elevation while over beaches:

2000

- 27 November 2000 in a Beaver float-plane (*VH-IMU*) piloted by Rod Johnston between 06.44hr and 09.49hr. Weather: scattered clouds, moderate easterly wind.
- 28 November 2000 in a Cesna 206 Stationair 611 (*VH-KKW*) piloted by Trish Mahlberg between 05.58hr and 09.15hr. Weather: scattered clouds, light south-east wind.
- 29 November 2000 in a Cesna 206 Stationair 611 (*VH-KKW*) piloted by Trish Mahlberg between 05.50hr and 09.03hr. Weather: clear sky, light south-east wind.

2001

- 26 November 2001 in a Beaver float-plane (*VH-IMU*) piloted by Rod Johnston between 04.50hr and 10.10hr. Weather: overcast, light north-easterly wind.
- 27 November 2001 in a Beaver float-plane (*VH-IMU*) piloted by Rod Johnston between 05.20hr and 10.55hr. Weather: overcast to scattered clouds, light to variable north-easterly wind.
- 28 November 2001 in a Beaver float-plane (*VH-IMU*) piloted by Rod Johnston between 05.30hr and 11.250hr. Weather: scattered clouds, 15-18n south-easterly wind.

Dr Col Limpus was the principal observer on all flights. He was assisted by Steve Fisher (QPWS), Ken Griffin (MTW) and Les Kemp (MTW).

During the November 2000 surveys, an on-ground census team was present on Eimeo Beach, Halliday Bay, Newry Island, Rabbit Island, Smalley's Beach, Cape Hillsborough, Belmunda Beach, Lamberts Beach, Harbour Beach, Blacks Beach, Salonika Beach, Grasstree Beach, Penrith Island West, Penrith Island North, Bushy Island, Penrith Island and Wild Duck Island for the nights preceding each respective aerial survey to ground truth species identification and track counts made from the aircraft.

Bushy Island was excluded from overflight during the 2000 aerial survey because of concerns for disturbance of the seabird nesting by the aircraft. Because Bushy Island is the only known rookery within the survey area with annual *C. mydas* nesting (Limpus 1985), an on-ground team was placed at the island to census turtle nesting while the 2000 aerial survey was in progress. Additional ground survey data from the study area have been reported previously (Limpus 1985; Limpus *et al.* 2002a;

Parmenter and Limpus 1995). During the 2001 survey, Bushy Island was again not surveyed from the air. However, the survey team landed from the float-plane and surveyed the island on foot (Appendix 1).

2.3 Data

The relevant turtle census and distributional data from these aerial surveys and on-ground census studies have been summarised within TURTDATA, the QPWS Turtle Database. This is a GIS compatible, relational database that quantitatively summaries temporal and spatial nesting data for each marine turtle species in Australia at their respective individual nesting beaches. TURTDATA is annually updated with new data gathered by Queensland Turtle Conservation teams conducting annual census and nesting survey studies at a large series of rookeries throughout eastern and northern Australia. Data from previously published and unpublished reports also are being validated and, where relevant, added to TURTDATA. The geographical locations within this database have been displayed using ArcView GIS software (Anon 1996).

The estimated sizes of the nesting populations were coded on an approximate logarithmic scale (Table 2). For each rookery, an order of magnitude estimate was made of the number of turtles expected to be encountered had a nightly tagging census been conducted for an entire nesting season. An estimate was made for each species at each beach. Except for those beaches with rigorous tagging census studies, estimation of the size of the annual nesting populations has been subjective. Based on the senior author's 30yr of experience in tagging nesting turtles, the counts of new and old tracks were used to estimate the number of nesting female turtles that could be tagged on each site if a total tagging census had been conducted for an entire nesting season. The estimates were made with several assumptions:

- that each population had been sampled at the high density period of the nesting season (Limpus 1985; Limpus *et al.* 2002a).
- that the nesting success for each area is in the "average" range of about 60-80%. If nesting success is excessively low, i.e. most turtles failing to lay eggs on a nesting crawl, then the size of the annual nesting population will be over estimated. The reverse would apply if there was exceptionally high nesting success.

Table 2. Database coding used to summarise the estimated size of the annual nesting population for each species of marine turtles for each beach surveyed.

Code	Size of the annual nesting population
0	nil or sporadic nesting
1	1-10 nesting females
2	10-100 nesting females
3	100-500 nesting females
4	500-1000 nesting females
5	1000-5000 nesting females
6	5000-10000 nesting females
7	10000-100000 nesting females
8	>100000 nesting females
-1	species present but not quantified
-9	no data available

For those rookeries for which a tagging census was conducted through the period of peak nesting density for the species, the mean nightly track count was calculated as an index of the size of the total annual nesting population. At beaches in the Mackay area, the total number of clutches laid has been used as the index of the size of the annual nesting population. Mackay Turtle Watch Project supplied long-term census data from their patrolled beaches. The Wild Duck Island long-term

census data was obtained from the Central Queensland University Turtle Research Project conducted by one of us (CJP).

3. Results

The mainland coast from Broad Sound northward to Repulse Bay and approximately all adjacent islands were surveyed for turtle nesting during three days of aerial survey during 27-29 November 2000. The flight path for each day is summarised in Figure 1. This same area was resurveyed over three days in November 2002 with an expansion of the surveyed area to encompass the Percy Islands, Marble Island group and south to northern Shoalwater Bay. During the November 2001 surveys, there was reduced emphasis on examining islands shown in the 2000 surveys to have a low probability of supporting turtle nesting. The flight path for each day is summarised in Figure 2.

The dates of the flights in November 2000 were delayed by two days because of very heavy rain in the region. This rain and associated wind would have obscured most turtle tracks from prior to or during the rain period. In addition, on most of the mainland beaches on the morning of the first flight, local residents wiped out the tracks from the nesting turtles in an attempt to conceal the nests from people who may wish to interfere with the eggs. This action was not reported to the survey team until after the first day's survey was completed. As a consequence, some of the low-density mainland nesting beaches had a lower count of new or old tracks than would normally have occurred.

The limited number of beaches for which nesting was recorded during the aerial surveys and for which a ground-truth count could be made of the nesting from the preceding night are summarised in Table 3 and Appendix 1. These data indicate that there is reasonably good agreement between the aerial survey counts and the counts on the beach.

Nesting by three species of marine turtle was identified during the two sets of surveys: *N. depressus*, *C. mydas* and *Caretta caretta*. The number of fresh tracks from the night preceding the survey of the beach, the number of old tracks that were more than one night old and the estimated size of the nesting population for the species for the beaches with recorded turtle nesting are summarised in Appendix 2. The rookeries are summarised by estimated size of the annual nesting population in Table 4.

There was a wide range in colour of sand on the nesting beaches. The brown sand beaches of Avoid Island (Photograph 1), Red Clay Island (Photograph 2, 3), Aquilla Island and Wild Duck Island and other continental islands in the Broad Sound area contrasted with the light-coloured sand beaches at Brampton Island (Photograph 4) Penrith Island, Cockermouth Island and Rabbit Island and other continental islands in the northern part of the surveyed area. The mainland nesting beaches near Mackay were intermediate in colour (Photograph 5). Bushy Island, being a coral cay, had a white sand beach (Photograph 6).

Table 3. Ground truth data: number of turtle tracks per night recorded by the on-ground teams at the rookeries during the period of the aerial survey. In parenthesis are track counts from the night before recorded during the aerial surveys. Only flatback turtles, *Natator depressus*, were recorded at these ground-truth beaches during the survey period, both on the beach and from the air.

Rookery	26 Nov	27 Nov	28 Nov
Rabbit Is	0	1 (1)✓	0 (0)
Seaforth	0	0	0 (0)
Newry Island	1	0	0 (0)
Ball Bay	0	1	0 (0)
Halliday Bay	3 (3)✓	0	2* (1)
Smalleys Beach	0	2	0 (0)
Cape Hillsborough	0	0	1 (0)
Belmunda	0	0	0 (0)
Eimeo	1	0	0 (0)
Blacks Beach	3*(0)	0	0 (0)
Lamberts Beach	1*(0)	0	0
Harbour Beach	0 (0)	0	0
Hay Point	0 (0)	0	0
Salonika	1*(0)	0	0
Grasstree Beach	0 (0)	1	0
Campwin	0 (0)	0	0
Sarina Beach	0 (0)	0	0
Penrith Island West	0 (0)	0	0
Penrith Island North	0 (0)	0	0
Bushy Atoll	0	0	0
Wild Duck Is	-	4 (4)	-

- ✓ tracks from previous nights that were detected during the aerial survey more than 24hr after nesting had occurred.
 * tracks wiped out by locals before the aerial survey.

Table 4. Marine turtle nesting sites recorded during the November 2000 and 2001 surveys. * Denotes that the rookery is within a National Park or Conservation Park. See Appendix 2 for a description of the number of tracks recorded and the location for each beach within these rookeries.

Species	Estimated size of annual nesting population		
	1-10 females per year	10-100 females per year	100-500 females per year
Flatback turtle, <i>Natator depressus</i>			
	Ball Bay	Infelix Islets *	Wild Duck Island (nth beaches) *
	Bucasia Beach	Flock Pigeon Island *	Avoid Island (3 beaches)
	Beach north of Carmilla Creek	Aquilla Island *	
	Beach south of Oconnell River	Red Clay Island*	
	Carlisle Island *	Brampton Island * (SW beach)	
	Connor Islet (NW beach)	St Bee's Island *	
	Curlew Island *	Rabbit Island *	
	Freshwater Point (sth beach)	Cockermouth Island *	
	Harbour Beach South	Penrith Island * (west beach)	
	Hay Point Beach	Wigton Island * (3 beaches)	
	Long Island * (east beach)	Halliday Bay	
	Hunter Island	Belmunda	
	Notch Point Beach	Blacks Beach	
	Oyster Isle	All Bay Beach (Stanage Bay area)	
	South Percy Island * (NW beach)	Lingham Island	
	Quail Island (NW beach)	Collins Island	
	Repulse Island, South *	Barnborough Island	
	Salonika Beach	Tynemouth Island	
	Shoalwater Bay (Arthur Point)	Marble Island	
	Shoalwater B (Stanage to Broom Head: 4 beaches)		
	Sunday Beach north of Cattle Ck		
	Temple Island		
	Ten Mile Beach		
	Turn Island (2 beaches)		
	Williamsons Beach		
Green turtle, <i>Chelonia mydas</i>			
	Connor Islet	Percy Island, Middle	Bushy Island *
	Double Island (mid west beach)	Percy Island, Northeast *	Pine Peak Island *
	Knight Island (west)	Lingham Island	South Percy Island *
	Barnborough Is. (Orchid Beach)	Collins Island	
	Penrith Island * (west beach)	Calder Island *	
	Shoalwater Bay (sth of Lingham)	Scawfell Island *	
	Wigton Island * (NW beach)	Curlew Island *	
	Williamsons Beach		
Loggerhead turtle, <i>Caretta caretta</i>			
	Bushy Island*	-	-
	South Percy Island*		

3.1 *Natator depressus*

Two major rookeries, each estimated to support several hundred nesting females per year, were identified: Wild Duck and Avoid Islands (Table 4, Figure 2). In addition, 19 minor rookeries, each estimated to support tens of nesting females per year, and 25 peripheral rookeries, each estimated to support less than ten nesting females per year, were identified (Table 4, Figure 3).

Although no tracks were recorded during the survey periods, Mackay Turtle Watch historical data indicate that North Harbour Beach, Sarina Beach, Dewars Beach, Seaforth, and Smalleys Beach all support 1 – 10 nesting females annually.

3.2 *Chelonia mydas*

Three significant rookeries, each estimated to support several hundred nesting females per year, were identified: Bushy Island, Pine Peak Island and South Percy Island (Table 4, Figure 4). In addition, seven minor rookeries, each estimated to support tens of nesting females per year, and eight peripheral rookeries, each estimated to support less than ten nesting females per year, were identified (Table 4, Figure 4).

In addition, Mackay Turtle Watch field teams recorded a nesting green turtle on each of Halliday Bay and Rabbit Island during the 2000/2001 breeding season.

3.3 *Caretta caretta*

Two peripheral rookeries, each estimated to support less than ten nesting females per year, were identified: Bushy Island and South Percy Island (Table 4, Figure 5).

4 Discussion

The annual nesting population at eastern Australian *N. depressus* rookeries fluctuates moderately from season to season (Limpus *et al.* 2002a, Figure 6). The population size for nesting *N. depressus* during the 2000-2001 breeding season was at a low to medium level relative to census data from rookeries within the census area in recent years (Figure 6). The size of the annual nesting populations estimated within the present study are therefore presumed to represent the low to medium level of nesting density that can be expected at these rookeries. Wild Duck Island and Avoid Island support two of the three largest *N. depressus* nesting populations in eastern Australia (present study; Limpus *et al.* 2002a). The *N. depressus* rookeries of the northern Broad Sound and Shoalwater Bay area support the major part of the breeding by the eastern Australian stock for the species.

The wide range in sand colour can be expected to provide sand temperatures at nest depth that will differ by two or more degrees between the extremes in beach colour types (Limpus *et al.* 1983c). This is expected to provide a predictable major nest-temperature mosaic among the rookeries of the eastern Australian *N. depressus* stock. This temperature mosaic, because of temperature dependent sex determination, will contribute to a consistent mix of male and female hatchlings within the total population. The major rookeries of Wild Duck and Avoid Islands are expected to produce mostly female hatchlings, given the darker sands on these nesting beaches.

Nesting densities of *C. mydas* at eastern Australian rookeries fluctuate over three orders of magnitude between breeding seasons and in approximate unison in response to *El Niño* Southern Oscillation (ENSO) climate change (Limpus and Nicholls, 2000). The 2000-2001 breeding season had one of the lowest densities of *C. mydas* nesting recorded in eastern Australia since census studies began in the 1960s (Figure 7). This low level of nesting expected given the extreme La Nina

event of 1998. In very low density nesting seasons like the 2000-2001 season, all rookeries can be expected to have very reduced numbers of nesting turtles. As a consequence it is not unexpected that few nestings of *C. mydas* nesting were recorded during this survey with in an area that is on the margin of the principal nesting distribution for the southern Great Barrier Reef *C. mydas* stock (Norman *et al.* 1994). In contrast, the 2001-2002 breeding season saw *C. mydas* nesting density return to a medium level (Figure 7). Therefore the results from the November 2001 surveys should provide an indication of the number of nesting *C. mydas* that can be expected at these rookeries in an approximately average density nesting season. The *C. mydas* nesting on the Percy Islands and Bushy Island represents the northern limit for significant nesting within the breeding range of the southern Great Barrier Reef stock.

The Mackay region is at the northern extremity of the distribution of *C. caretta* nesting in eastern Australia (Limpus, 1985). The density of *C. caretta* nesting at Bushy Island has declined from tens of nesting females per year in the 1970s (Limpus 1985) to less than 10 per year. This is consistent with the major declines witnessed at the other eastern Australia rookeries over the same period (Limpus and Reimer, 1994). This latter decline was attributed primarily to mortality factors at sea rather than from problems on the nesting beaches.

A major portion of all the marine turtle nesting within the Shoalwater Bay to Repulse Bay area occurs with National Parks or Conservation Parks (Table 4). For *N. depressus*, one of the two major rookeries (Wild Duck Island), 10 of the 19 minor rookeries and five of the 25 peripheral rookeries are within National Parks. The recently declared Broad Sound National Park has included an appreciable amount of *N. depressus* nesting habitat within the National Park estate. For *C. mydas*, all three of the significant rookeries (Bushy Island, Pine Peak Island and South Percy Island), four of the seven minor rookeries and two of the eight peripheral rookeries were within National Parks. The two identified very low density nesting areas for *C. caretta* both lie with National Parks. In contrast, many of the *N. depressus* nesting beaches along the mainland coast near Sarina and Mackay are backed by coastal development (Photograph 5) with associated changes in light horizons and the potential for increased human disturbance of the nesting turtles and their habitat.

The only area of the Queensland coast that remains unsurveyed for marine turtle nesting is the area encompassing the Defence Forces Shoalwater Bay Army Training Area south of the Percy islands south to Stockyard Point and the Duke Island Group between Wild Duck Island and the marble Group. It is expected that this unsurveyed area will contain *N. depressus* and *C. mydas* rookeries.

5 Recommendations

- A. Avoid Island, being one of the three most important rookeries for the eastern Australian *N. depressus* stock, warrants consideration for negotiation of a conservation agreement between the land owners and QPWS.
- B. It is recommended that representative significant beaches with dark coloured and light coloured sand be monitored for consistency of sand temperatures and for sex ratio of resulting hatchlings.
- C. To complete the mapping of marine turtle breeding in eastern Australia, it is recommended that a survey be undertaken of the distribution and abundance by species of nesting within the area encompassing the Defence Forces Shoalwater Bay Army Training Area south of the Percy islands south to Stockyard Point and the Duke Island Group.

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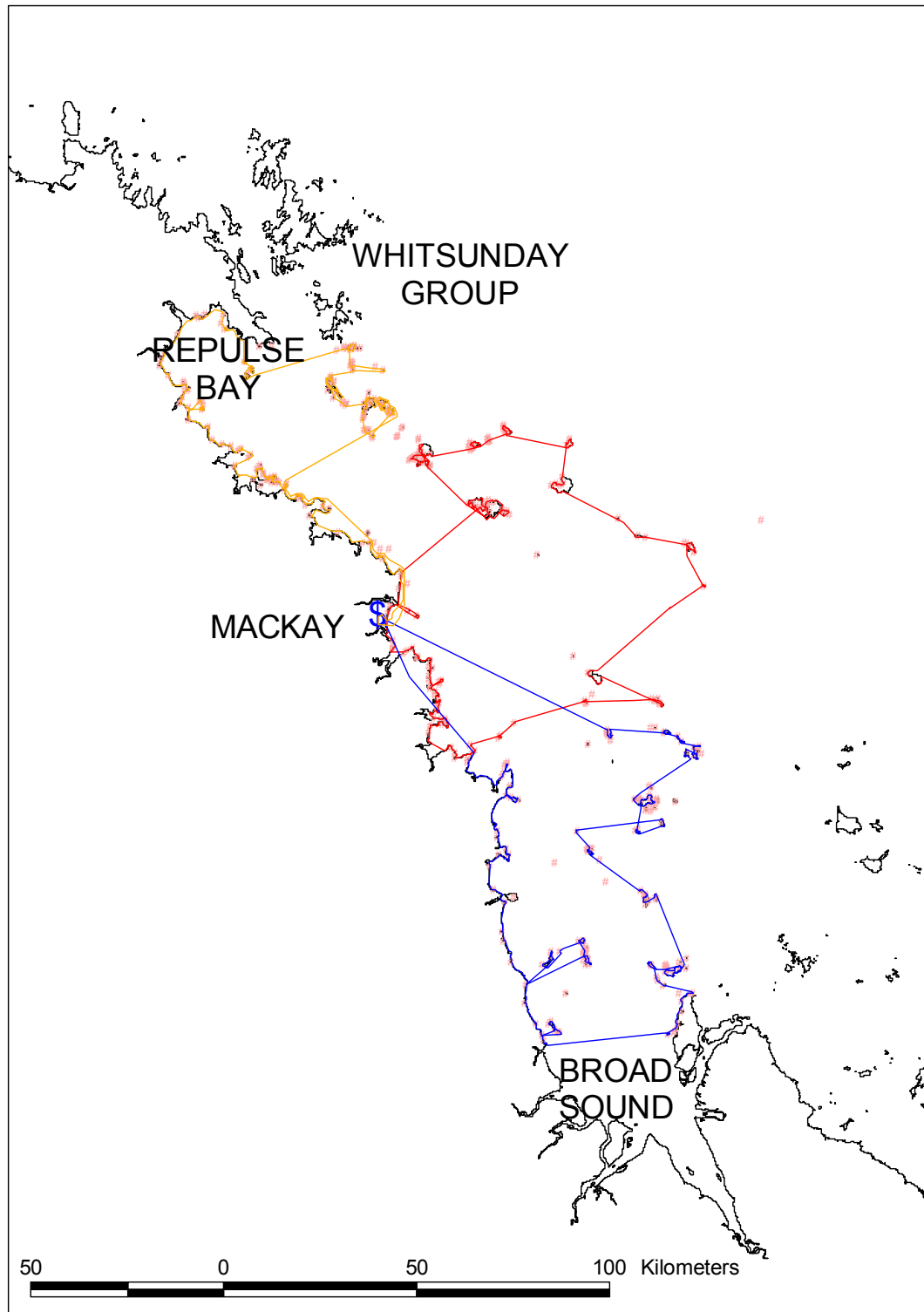


Figure 1. Flight paths for the three days of aerial survey out of Mackay in November 2000: 27th red; 28th blue; 29th yellow. Dots denote the beaches and islands examined. See text for detail.

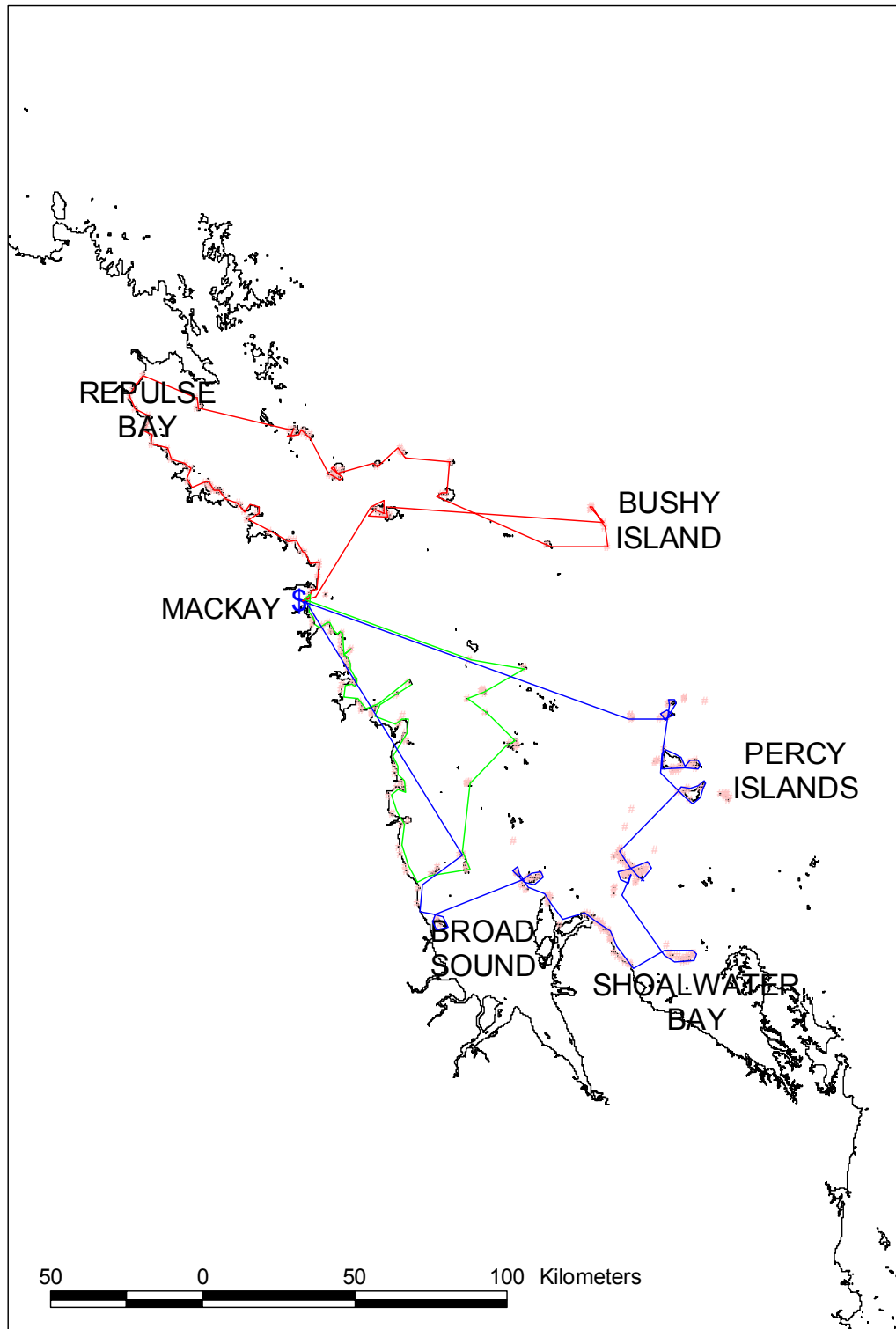


Figure 2. Flight paths for the three days of aerial survey out of Mackay in November 2001: 26th red; 27th green; 29th blue. Dots denote the beaches and islands examined. See text for detail.

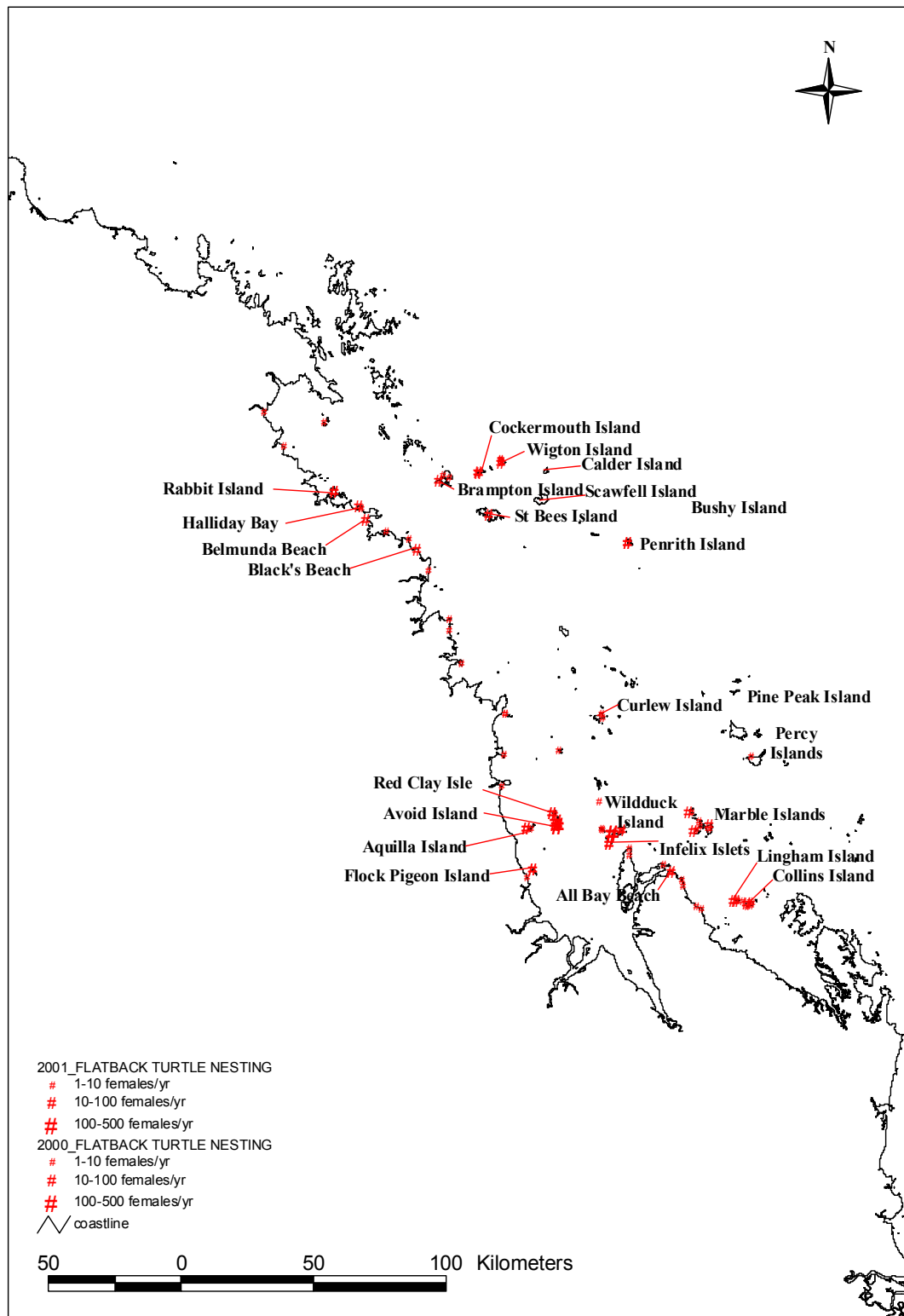


Figure 3. Distribution and size of flatback turtle, *Natator depressus*, nesting populations recorded during the November 2000 and 2001 aerial surveys.

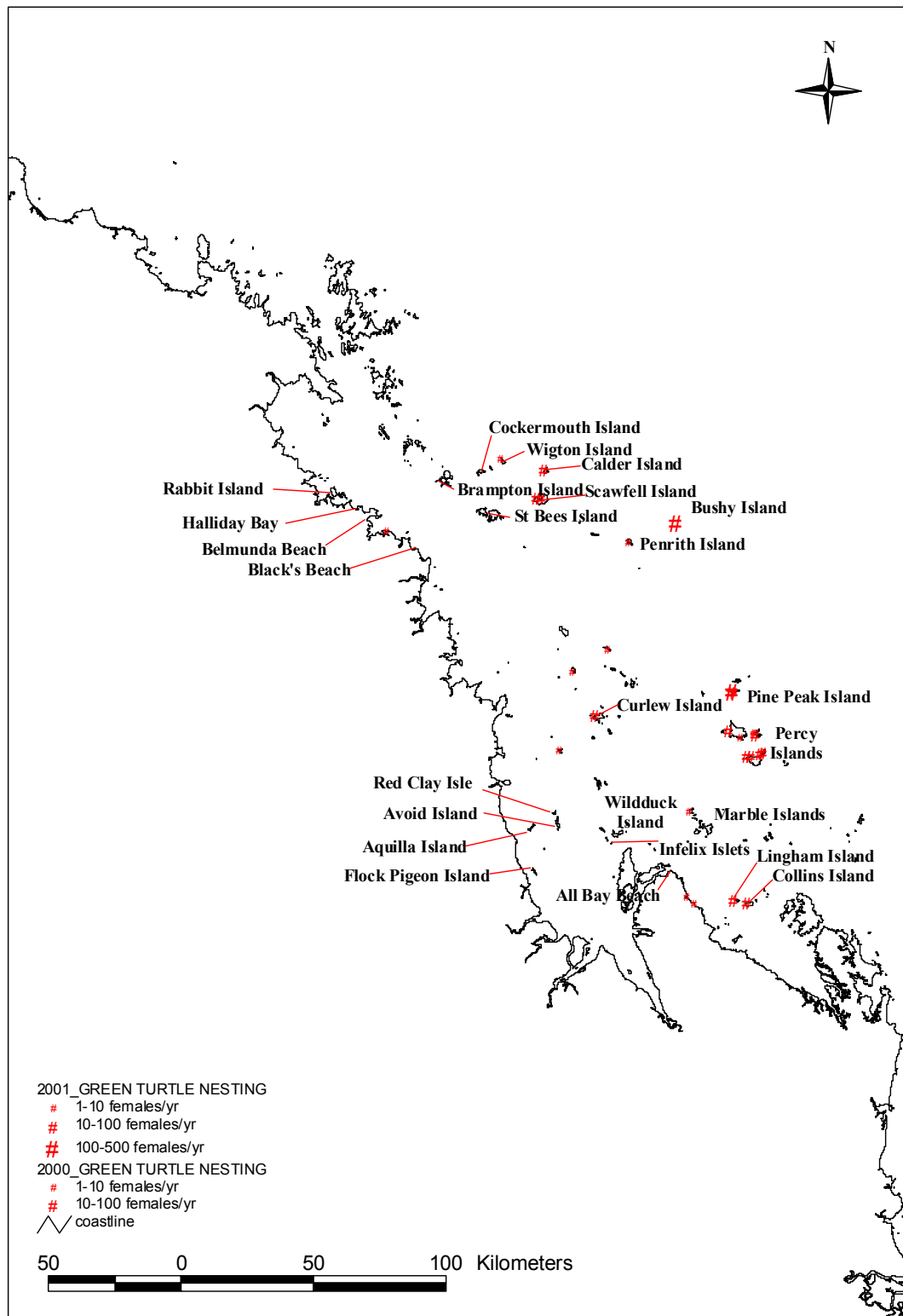


Figure 4. Distribution and size of green turtle, *Chelonia mydas*, nesting populations recorded during the November 2000 and 2001 aerial surveys.

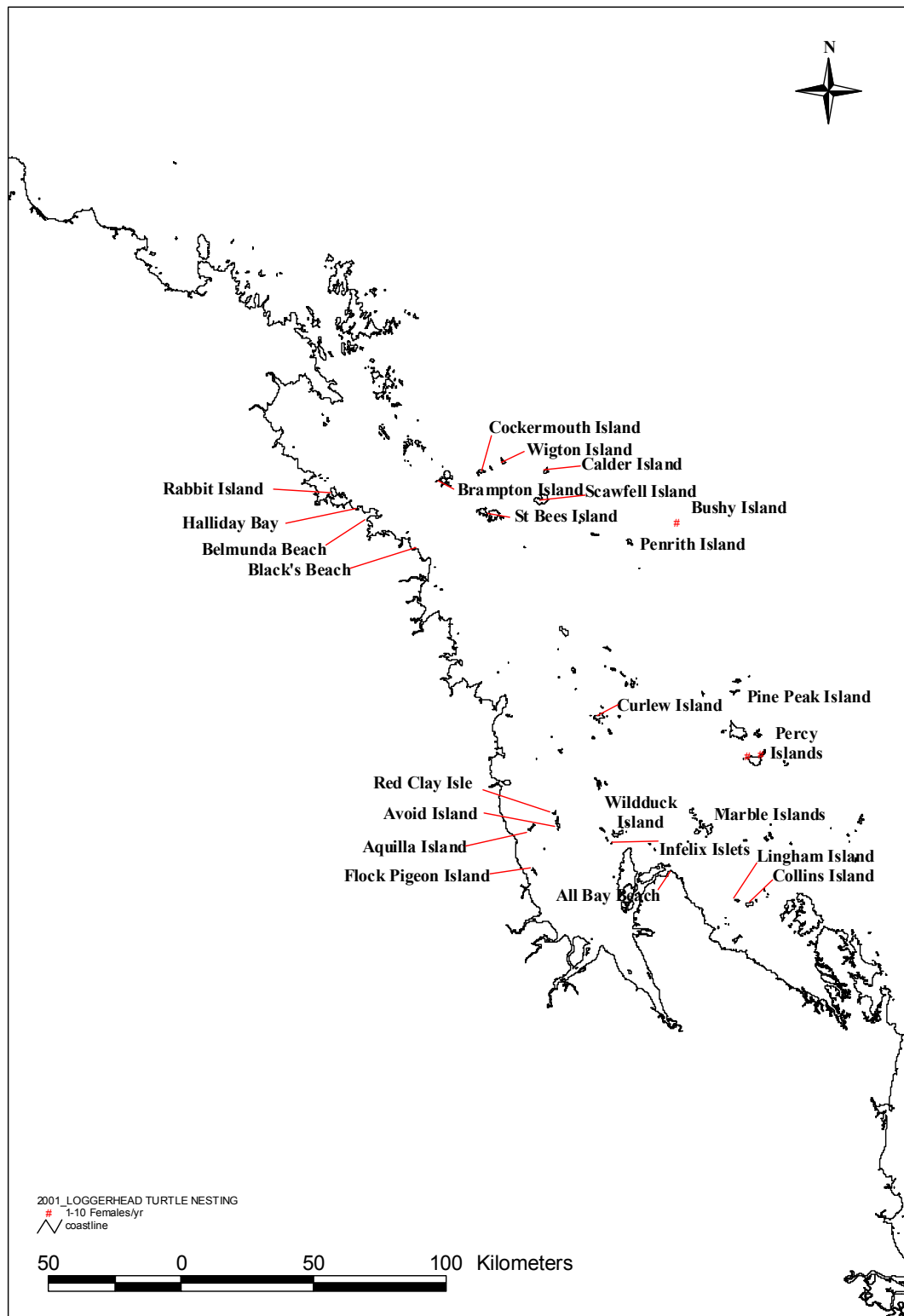


Figure 5. Distribution and size of loggerhead turtle, *Caretta caretta*, nesting populations recorded during the November 2000 and 2001 aerial surveys.

FLATBACK TURTLE (*Natator depressus*) NESTING CENSUS MACKAY-SARINA DISTRICT BEACHES

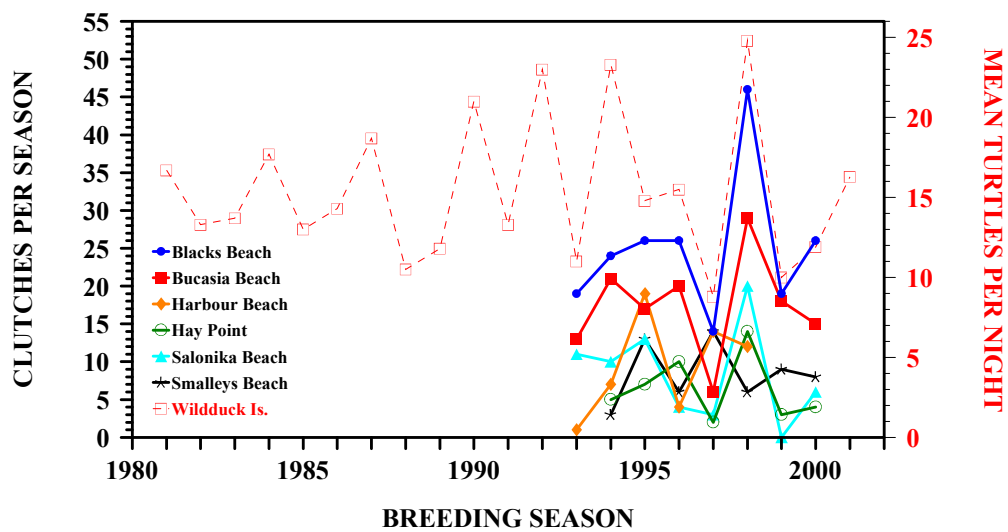


Figure 6. Flatback turtle nesting census data from Mackay Turtle Watch patrolled beaches and from Wild Duck Island. At each of the Mackay Turtle Watch beaches the census metric is the total number of clutches laid per season. At Wild Duck Island the census metric is the mean number of beaching per night by nesting females during the last week of November and the first week of December.

Chelonia mydas HERON ISLAND, AUSTRALIA TOTAL ANNUAL NESTING POPULATION

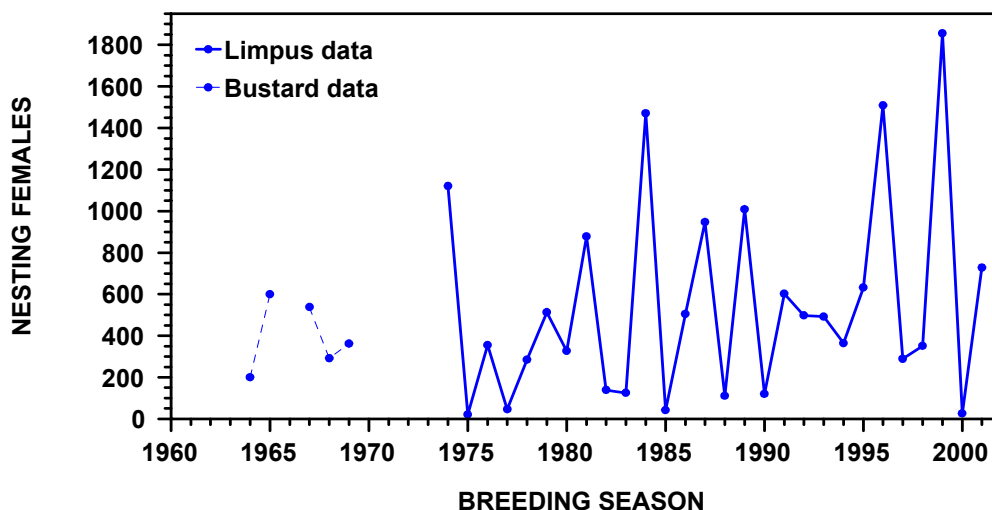


Figure 7. Fluctuations in the size of the annual nesting population of *Chelonia mydas* at Heron Island. The Heron Island nesting population is used as the index population for the southern *C. mydas* stock and is monitored with a saturation tagging census.

Photographs of turtle rookeries surveyed during November 2000 and 2001.



Photograph 1. Avoid Island, south eastern beach, 27 November 2001.



Photograph 4. Long Beach on the southern side of Brampton Island, 26 November 2001.



Photograph 2. Red Clay Island, eastern beaches, 28 November 2001.



Photograph 5. Grasstree Beach, 28 November 2001.



Photograph 3. Red Clay Island, western beach, 28 November 2001.



Photograph 6. Bushy Island, 26 November 2001.

APPENDIX 1

QUEENSLAND TURTLE CONSERVATION PROJECT MACKAY TURTLE WATCH AERIAL SURVEY, 26-28 NOVEMBER 2001 GROUND TRUTH SURVEYS

During the aerial surveys, several islands were inspected on the ground using the survey aircraft (Beaver float-plane) to access the islands.

BUSHY ISLAND: 26 November 2001, 07:45hr to 08:45hr

We landed over the reef-flat and taxied to the island.

The beach was examined during one walk of the island perimeter.

The *Pisonia* forest was very dry and very defoliated. Some *Pandanus* were dead. The island was eroding on the eastern side with *Pandanus* and *Pisonia* trees falling onto the beach. In contrast, on the leeward side the beach has been accreting with new growth of *Casuarina*, *Argusium* and *Scovola* encroaching on this area.

Table A. Comparison of air survey and beach track counts on Bushy Island, 26 November 2001. * Aerial count not undertaken because of GBRMPA restrictions on flights near the island.

Survey method	Tracks from nesting turtles		Hatchling clutches
	From <25 Nov	Night of 25 Nov	Night of 25 Nov
Aerial count*	-	-	-
Ground count			
<i>Chelonia mydas</i>	53	13	0
<i>Caretta caretta</i>	2	0	0

AVOID ISLAND: 27 November 2001, 06:51hr to 08:59hr

We landed on the airstrip rather than on the water. The island was uninhabited. Vehicles (Landrover, tractor-slasher and motorbike) in disrepair were parked under the trees at the inland end of the airstrip. A shed and house appeared to be in good repair but were not inspected.

The south-eastern beach only was inspected using an existing access track.

The frontal dune vegetation was mainly scattered *Casuarina* and *Pandanus* with little grass or herb cover in the turtle nesting area. On top of and behind the dunes was a belt of vine thicket. The beach was composed of red-brown mineral sand.

All nesting in evidence was by flatback turtles, *Natator depressus*. This was also the only species identified from the aircraft.

Track counts: The track count from the beach demonstrated that the track count from the air was reliable (Table B). The single discrepancy resulted from the similarity in height of the recent day and night high tides making interpretation difficult for a track of turtle that had returned to sea on the peak of the previous night's high tide.

Table B. Comparison of air survey and beach track counts on the south-eastern beach of Avoid Island, 27 November 2001.

Survey Method	Tracks from nesting turtles		Hatchling clutches
	From <26 Nov	Night of 26 Nov	Night of 26 Nov
Aerial count	22	5	1
Ground count	21	6	1

The following birds were identified on the island:

Torresian Imperial pigeon
 Bar shouldered dove
 Rose-crowned fruit-pigeon
 Rainbow Bee-eater
 Welcome swallow
 Brown quail
 Zitting cisticola
 Tawny grassbird
 Willy wagtail
 Mangrove Honeyeater

Hatchling emergence: One emerged clutch was examined (Table C). The turtle had nested in a bare sand area of the dunes that was impacted by *Casuarina* roots.

Table C. Emergence success of the examined flatback turtle clutch.

	Within nest
Clutch count	51 eggs + 2 yolkless
Emerged hatchlings	33
Live hatchlings in nest	7 (caught in roots)
Dead hatchlings in nest	2 (caught in roots)
Unhatched eggs	2
Undeveloped eggs	7

There were 25 obvious hatchling tracks radiating from the nest. The tracks indicated that 3 of these hatchlings were taken by ghost crabs (*Ocypode ceratophthalmus*) as they crossed the beach.

Although there were tracks from domestic cats on the beach, there was no indication that cats had examined the emerged clutch.

APPENDIX 2.

Print out from TURTDATA file: CQYYSURV.dbf

Table 5. Beaches identified as nesting beaches during the aerial survey of marine turtle nesting distribution in Queensland: Broad Sound to Repulse Bay, Central Queensland, 27-29 November 2000. See text for details: estimate = the estimated size of the annual nesting population (defined in Table 1); fresh tracks = the number of turtle beachings for the night immediately preceding the aerial survey; old tracks = the number of turtle tracks from more earlier than the night preceding the aerial survey. Only *C. mydas* and *N. depressus* nesting were recorded during this survey.

IDENTIFIED NESTING BEACHES

Date	Locality	Latitude	Longitude	<i>Chelonia mydas</i>			<i>Natator depressus</i>		
				estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks
27/11/2000	COCKERMOUTH IS: MID WEST BEACH	-20.7778	149.3944	0	0	0	2	2	1
27/11/2000	WIGTON ISLAND: MID WEST BEACH	-20.7423	149.4708	0	0	0	1	0	2
27/11/2000	WIGTON ISLAND: NW WEST BEACH #1	-20.7356	149.4655	0	0	0	1	0	3
27/11/2000	PENRITH ISLAND: WESTERN BEACH	-21.0155	149.8995	0	0	0	2	0	4
28/11/2000	CURLEW ISLAND: NW BEACH	-21.6040	149.7897	2	3	0	0	0	0
28/11/2000	CONNOR ISLET: NW SHINGLE BEACH	-21.7212	149.6631	1	0	1	0	0	0
28/11/2000	WILDDUCK ISLAND: SETTLEMENT BCH	-22.0020	149.8510	0	0	0	3	4	numerous
28/11/2000	WILDDUCK ISLAND: EAST BEACH	-21.9927	149.8780	0	0	0	1	0	1
28/11/2000	TURN ISLAND: MID EAST BEACH	-21.9862	149.8107	0	0	0	1	0	1
28/11/2000	INFELIX ISLETS: SOUTH	-22.0361	149.8399	0	0	0	2	1	2
28/11/2000	LONG IS: NORTH BEACH	-22.0541	149.9027	0	0	0	1	0	2
28/11/2000	FLOCK PIDGEON ISLAND: EAST BCH	-22.1214	149.5767	0	0	0	2	0	16
28/11/2000	AQUILA ISLAND: WESTERN BEACH	-21.9886	149.5573	0	0	0	2	1	6
28/11/2000	RED CLAY ISLE: WESTERN BEACH	-21.9329	149.6424	0	0	0	2	2	3
28/11/2000	AVIOD ISLAND: NE BEACH	-21.9673	149.6598	0	0	0	3	1	20
28/11/2000	AVIOD ISLAND: MID EAST BEACH	-21.9744	149.6639	0	0	0	1	0	2
28/11/2000	AVIOD ISLAND: SE EAST BEACH	-21.9771	149.6643	0	0	0	3	0	25
28/11/2000	TEMPLE ISLAND	-21.5986	149.4844	0	0	0	1	1	0
28/11/2000	SUNDAY BEACH	-22.1540	149.5557	0	0	0	1	0	1
29/11/2000	RABBIT ISLAND: SE BEACH	-20.8448	148.9059	0	0	0	2	0	3
29/11/2000	HALLIDAY BAY	-20.8948	148.9876	0	0	0	2	1	3
29/11/2000	BUCASIA BEACH	-21.0040	149.1567	0	0	0	1	0	1

Table 6. Beaches identified as nesting beaches during the aerial survey of marine turtle nesting distribution in Queensland: Northern Shoalwater Bay to Repulse Bay, Central Queensland, 26-28 November 2000. See text for details: estimate = the estimated size of the annual nesting population (defined in Table 1); fresh tracks = the number of turtle beachings for the night immediately preceding the aerial survey; old tracks = the number of turtle tracks from more earlier than the night preceding the aerial survey. *C. mydas*, *N. depressus* and *Caretta caretta* nesting were recorded during this survey.

IDENTIFIED NESTING BEACHES												
Date	Locality	Latitude	Longitude	<i>Chelonia mydas</i>			<i>Natator depressus</i>			<i>Caretta caretta</i>		
				estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks
27/11/2001	AQUILA ISLAND:EASTERN BEACH	-21.9851	149.5716	0	0	0	1	1	0	0	0	0
27/11/2001	AQUILA ISLAND:WESTERN BEACH	-21.9886	149.5573	0	0	0	2	4	8	0	0	0
27/11/2001	AVIOD ISLAND:MID EAST BEACH	-21.9744	149.6639	0	0	0	2	2	2	0	0	0
27/11/2001	AVIOD ISLAND:NE BEACH	-21.9673	149.6598	0	0	0	1	0	2	0	0	0
27/11/2001	AVIOD ISLAND:SE EAST BEACH	-21.9771	149.6643	0	0	0	3	5	22	0	0	0
26/11/2001	BALL BAY	-20.9023	148.9945	0	0	0	1	1	0	0	0	0
27/11/2001	BEACH NTH OF CARMILLA CREEK	-21.8431	149.4704	0	0	0	1	0	1	0	0	0
26/11/2001	BEACH SOUTH OF OCONNELL R	-20.5763	148.6671	0	0	0	1	0	1	0	0	0
26/11/2001	BELMUNDA BEACH	-20.9403	149.0137	0	0	0	2	1	1	0	0	0
26/11/2001	BLACKS BEACH	-21.0399	149.1861	0	0	0	2	1	1	0	0	0
26/11/2001	BRAMPTON ISLAND:S WEST BEACH	-20.8076	149.2594	0	0	0	2	1	2	0	0	0
26/11/2001	BUSHY ISLAND	-20.9500	150.0667	3	13	53	0	0	0	1	0	2
26/11/2001	CALDER ISLAND:WESTERN BEACH	-20.7723	149.6137	2	1	4	0	0	0	0	0	0
26/11/2001	CARLISLE ISLAND:MARYPORT BEACH	-20.7904	149.2746	0	0	0	1	0	1	0	0	0
26/11/2000	CARLISLE ISLAND:SQUEEKY BEACH	-20.7960	149.2952	0	0	0	1	0	4	0	0	0
26/11/2001	COCKERMOUTH IS:STH WEST BEACH	-20.7812	149.3967	0	0	0	2	1	10	0	0	0
28/11/2001	COLLINS ISLAND:EAST END	-22.2368	150.3227	0	0	0	1	0	1	0	0	0
28/11/2001	COLLINS ISLAND:MID NORTH	-22.2380	150.3053	2	1	1	2	1	3	0	0	0
28/11/2001	COLLINS ISLAND:NORTH EAST	-22.2347	150.3134	0	0	0	1	0	2	0	0	0
28/11/2001	COLLINS ISLAND:SOUTHERN	-22.2467	150.3189	0	0	0	1	0	1	0	0	0
28/11/2001	COLLINS ISLAND:WESTERN END	-22.2499	150.3036	0	0	0	1	0	3	0	0	0
27/11/2001	CONNOR ISLET: NW BEACH	-21.7218	149.6653	0	0	0	1	1	1	0	0	0
27/11/2001	CURLEW ISLAND:EAST BEACH	-21.5995	149.8087	0	0	0	1	0	3	0	0	0
27/11/2001	CURLEW ISLAND:SE BEACH #1	-21.6101	149.8143	0	0	0	1	0	1	0	0	0
27/11/2001	DOUBLE ISLAND:MID WEST BEACH	-21.3788	149.8307	1	0	2	0	0	0	0	0	0
28/11/2001	FLOCK PIDGEON ISLAND:EAST BCH	-22.1214	149.5767	0	0	0	2	6	18	0	0	0
27/11/2001	FRESHWATER POINT:STH	-21.4253	149.3349	0	0	0	1	1	1	0	0	0
26/11/2001	HARBOUR BEACH SOUTH	-21.1107	149.2235	0	0	0	1	0	1	0	0	0
27/11/2001	HAY POINT BEACH	-21.2777	149.2949	0	0	0	1	0	2	0	0	0
28/11/2001	INFELIX ISLETS:SOUTH	-22.0361	149.8399	0	0	0	2	4	0	0	0	0
27/11/2001	KNIGHT ISLAND:WEST #1	-21.4533	149.7100	1	0	1	0	0	0	0	0	0
28/11/2001	LINGHAM IS:EASTERN BEACH	-22.2317	150.2731	0	0	0	1	1	0	0	0	0
28/11/2001	LINGHAM IS:NORTHERN BEACH	-22.2294	150.2598	2	2	2	2	0	5	0	0	0
28/11/2001	LINGHAM IS:SOUTH TO NW POINT	-22.2310	150.2663	0	0	0	2	2	3	0	0	0
28/11/2001	LONG IS:EAST BEACH	-22.0757	149.9056	0	0	0	1	0	1	0	0	0
28/11/2001	MARBLE GP:BARNBOROUGH:ORCHID B	-21.9310	150.1076	1	3	0	2	6	5	0	0	0
28/11/2001	MARBLE GP:BARNBOROUGH:TURTLE B	-21.9325	150.1148	0	0	0	1	0	3	0	0	0
28/11/2001	MARBLE GP:HUNTER IS:NW BCHS	-21.9639	150.1390	0	0	0	1	1	0	0	0	0
28/11/2001	MARBLE GP:HUNTER IS:WEST BCH	-21.9770	150.1422	0	0	0	1	0	1	0	0	0
28/11/2001	MARBLE GP:MARBLE IS:DAM BEACH	-21.9754	150.1752	0	0	0	2	2	3	0	0	0
28/11/2001	MARBLE GP:MARBLE IS:E BCH#1	-21.9848	150.1781	0	0	0	1	0	1	0	0	0

Table 6. Continued.

IDENTIFIED NESTING BEACHES

Date	Locality	Latitude	Longitude	<i>Chelonia mydas</i>			<i>Natator depressus</i>			<i>Caretta caretta</i>		
				estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks
28/11/2001	MARBLE GP:TYNEMOUTH IS:N BCH#1	-21.9894	150.1310	0	0	0	1	1	0	0	0	0
28/11/2001	MARBLE GP:TYNEMOUTH IS:SW BCH	-21.9962	150.1238	0	0	0	2	3	6	0	0	0
27/11/2001	NOTCH POINT BEACH	-21.7331	149.4791	0	0	0	1	0	1	0	0	0
28/11/2001	OYSTER ISLE	-22.2333	150.2869	0	0	0	1	1	0	0	0	0
26/11/2001	PENRITH ISLAND:WESTERN BEACH	-21.0155	149.8995	1	0	1	2	3	11	0	0	0
28/11/2001	PERCY:NTH EAST IS/STH BCH	-21.6698	150.3351	2	2	4	0	0	0	0	0	0
28/11/2001	PERCY:NTH EAST IS/WEST BCH	-21.6655	150.3263	1	0	2	0	0	0	0	0	0
28/11/2001	PERCY:SOUTH IS/NTH BEACH#1	-21.7331	150.3521	2	3	3	0	0	0	1	1	0
28/11/2001	PERCY:SOUTH IS/NTH BEACH#2	-21.7321	150.3595	2	2	1	0	0	0	0	0	0
28/11/2001	PERCY:SOUTH IS/NW BEACH#1	-21.7440	150.3033	2	2	2	0	0	0	1	0	1
28/11/2001	PERCY:SOUTH IS/NW BEACH#2	-21.7428	150.3184	2	3	14	1	0	1	0	0	0
28/11/2001	PERCY:SPUR BAY BCHS	-21.6788	150.2788	1	2	0	0	0	0	0	0	0
28/11/2001	PERCY:WEST BAY BCHS	-21.6563	150.2440	2	0	6	0	0	0	0	0	0
28/11/2001	PINE PEAK IS:BATTLE B BCH	-21.5225	150.2546	3	14	30	0	0	0	0	0	0
28/11/2001	PINE PEAK IS:SE BEACH	-21.5256	150.2593	1	0	1	0	0	0	0	0	0
28/11/2001	PINE PEAK IS:SW BEACH	-21.5266	150.2535	1	0	4	0	0	0	0	0	0
28/11/2001	PINE PEAK IS:W BEACH	-21.5229	150.2495	2	1	7	0	0	0	0	0	0
28/11/2001	QUAIL IS:NE BEACH,NORTHERN	-22.1105	150.0211	0	0	0	1	1	1	0	0	0
26/11/2001	RABBIT ISLAND:SE BEACH	-20.8448	148.9059	0	0	0	2	2	1	0	0	0
27/11/2001	RED CLAY ISLE:EAST BEACH #2	-21.9361	149.6513	0	0	0	1	2	0	0	0	0
27/11/2001	RED CLAY ISLE:WESTERN BEACH	-21.9329	149.6424	0	0	0	2	3	3	0	0	0
26/11/2001	REPULSE ISLAND:SOUTH	-20.6100	148.8671	0	0	0	1	1	1	0	0	0
27/11/2001	SALONIKA BEACH:NTH	-21.3133	149.2924	0	0	0	1	0	2	0	0	0
26/11/2001	SCAWFELL ISLAND:MID WEST BCH#2	-20.8664	149.6054	2	3	10	0	0	0	0	0	0
26/11/2001	SCAWFELL ISLAND:N WESTERN BCH	-20.8675	149.5894	2	2	6	0	0	0	0	0	0
26/11/2001	ST BEES ISLAND:WESTERN BEACH	-20.9236	149.4298	0	0	0	2	0	5	0	0	0
28/11/2001	SWB:"THE SHACKS" (STH LANGHAM)	-22.2193	150.0998	1	0	1	0	0	0	0	0	0
28/11/2001	SWB:2ND BEACH STH OF STANAGE B	-22.1606	150.0816	0	0	0	1	0	2	0	0	0
28/11/2001	SWB:ALL BAY BEACH	-22.1322	150.0474	0	0	0	2	3	10	0	0	0
28/11/2001	SWB:ARTHUR POINT BEACH	-22.1295	150.0435	0	0	0	1	2	0	0	0	0
28/11/2001	SWB:BAY NTH OF YENYARINDLE HUT	-22.2518	150.1331	0	0	0	1	0	2	0	0	0
28/11/2001	SWB:LANGHAM	-22.1805	150.0867	0	0	0	1	0	1	0	0	0
28/11/2001	SWB:NTH OF BROOM HEAD	-22.2587	150.1472	0	0	0	1	1	0	0	0	0
28/11/2001	SWB:STH OF LANGHAM #3	-22.2411	150.1214	1	0	1	0	0	0	0	0	0
27/11/2001	TEMPLE ISLAND	-21.5986	149.4844	0	0	0	1	0	2	0	0	0
26/11/2001	TEN MILE BEACH	-20.6899	148.7313	0	0	0	1	0	2	0	0	0
28/11/2001	TURN ISLAND (NW CORNER)	-21.8950	149.8028	0	0	0	1	0	2	0	0	0
28/11/2001	TURN ISLAND:STH EAST BEACH	-21.9901	149.8132	0	0	0	1	0	1	0	0	0
26/11/2001	WIGTON ISLAND:MID WEST BEACH	-20.7423	149.4708	0	0	0	2	0	5	0	0	0
26/11/2001	WIGTON ISLAND:NW WEST BEACH #1	-20.7356	149.4655	0	0	0	1	0	1	0	0	0
26/11/2001	WIGTON ISLAND:NW WEST BEACH#2	-20.7312	149.4657	1	1	not recorded	1	0	1	0	0	0

Table 6. Continued.

IDENTIFIED NESTING BEACHES												
Date	Locality	Latitude	Longitude	<i>Chelonia mydas</i>			<i>Natator depressus</i>			<i>Caretta caretta</i>		
				estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks	estimate	fresh tracks	old tracks
26/11/2001	WIGTON ISLAND:SW SMALL #3	-20.7451	149.4725	0	0	0	1	1	1	0	0	0
28/11/2001	WILDDUCK ISLAND:NW BEACH	-22.0020	149.8482	0	0	0	2	2	3	0	0	0
28/11/2001	WILDDUCK ISLAND:SETTLEMENT BCH	-22.0020	149.8510	0	0	0	3	numerous	numerous	0	0	0
28/11/2001	WILDDUCK ISLAND:STH EAST BEACH	-21.9956	149.8805	0	0	0	1	0	1	0	0	0
26/11/2001	WILLIAMSONS BEACH	-20.9783	149.0794	1	0	1	1	0	1	0	0	0