Vol. 3: 1–9, 2007

ENDANGERED SPECIES RESEARCH
Endang Species Res

Printed June 2007
Published online January 18, 2007

Migration routes and foraging behaviour of olive ridley turtles *Lepidochelys olivacea* in northern Australia

S. D. Whiting[1,5,*], J. L. Long[2], M. Coyne[3,4]

[1]WWF-Australia, PO Box 1268, Darwin, Northern Territory 0801, Australia
[2]Tiwi Land Council, PO Box 38545, Winnellie, Northern Territory 0821, Australia
[3]Marine Geospatial Ecology Lab, Nicholas School of Environment, Duke University, Durham, North Carolina 27708, USA
[4]SEATURTLE.ORG, 1 Southampton Place, Durham, North Carolina 27705, USA
[5]*Present address:* Marine Biodiversity Group, Natural Resources, Environment and the Arts, PO Box 41775, Casuarina, Northern Territory 0810, Australia

ABSTRACT: The foraging ecology of endangered olive ridley *Lepidochelys olivacea* sea turtles is poorly known in Australia, with only a limited knowledge of their foraging distribution inferred from captures in trawl net fisheries. We attached satellite transmitters to 8 olive ridley turtles in 2004 and 2005 at a nesting beach in Australia's Northern Territory to document their migratory routes and foraging behaviour. Three turtles moved up to 40 km from the nesting beach before renesting on the same beach within 12 to 23 d. The turtles made post-nesting migrations of 165 to 1050 km to 5 different foraging areas and used coastal, continental shelf and continental slope habitats. The use of one foraging area by 3 turtles, together with previous trawl data, indicate a predictable source of food in this area. Distinct foraging areas indicate that foraging behaviour differs from the meandering oceanic movements of turtles in the Pacific. During migration and foraging periods, turtles dived to the substrate with maximum depths of 150 to 200 m and maximum dive durations of 120 to 180 min. The locations of foraging areas overlapped with existing trawl fisheries and oil and gas exploration and mining.

KEY WORDS: Satellite tracking · Migration · Foraging · Olive ridley · Renesting · Inter-nesting · Australia

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INTRODUCTION

Olive ridley turtles *Lepidochelys olivacea* live in the Atlantic, Pacific and Indian oceans. They are classified as endangered in Australia under the Environment Protection and Biodiversity Act 1999 and internationally by the IUCN Red List (IUCN 2004). Very little is known about their biology in Australia, perhaps owing to the remoteness of their nesting beaches and because their foraging habitats appear to occur in turbid water of depths greater than 10 m, where surveys are difficult (Robins et al. 2002). The location of foraging areas are indicated from incidental fishery by-catch records (Robins et al. 2002), beach strandings (Guinea & Chatto 1992, Guinea et al. 1997) and captures in discarded fishing gear (Chatto et al. 1995). Data from the Northern Prawn Fishery (NPF), which stretches across northern Australia, indicate that adult-sized olive ridley turtles were frequently captured in this fishery prior to the introduction of Turtle Excluder Devices (TEDs) in 2000 (Poiner et al. 1990, Poiner & Harris 1996, Robins et al. 2002). Most were captured in the Gulf of Carpentaria, eastern Kimberley and several areas across the north of the Northern Territory (Fig. 1a). Another major foraging area for olive ridley turtles was indicated by a by-catch incident in shallow inshore waters in the eastern Joseph Bonaparte Gulf, where 85 of an estimated 250 carcasses washed ashore (Guinea & Chatto 1992). Other miscellaneous and stranding records indicate that non-nesting olive ridley turtles forage throughout

*Email: s_whiting@biomarine.com

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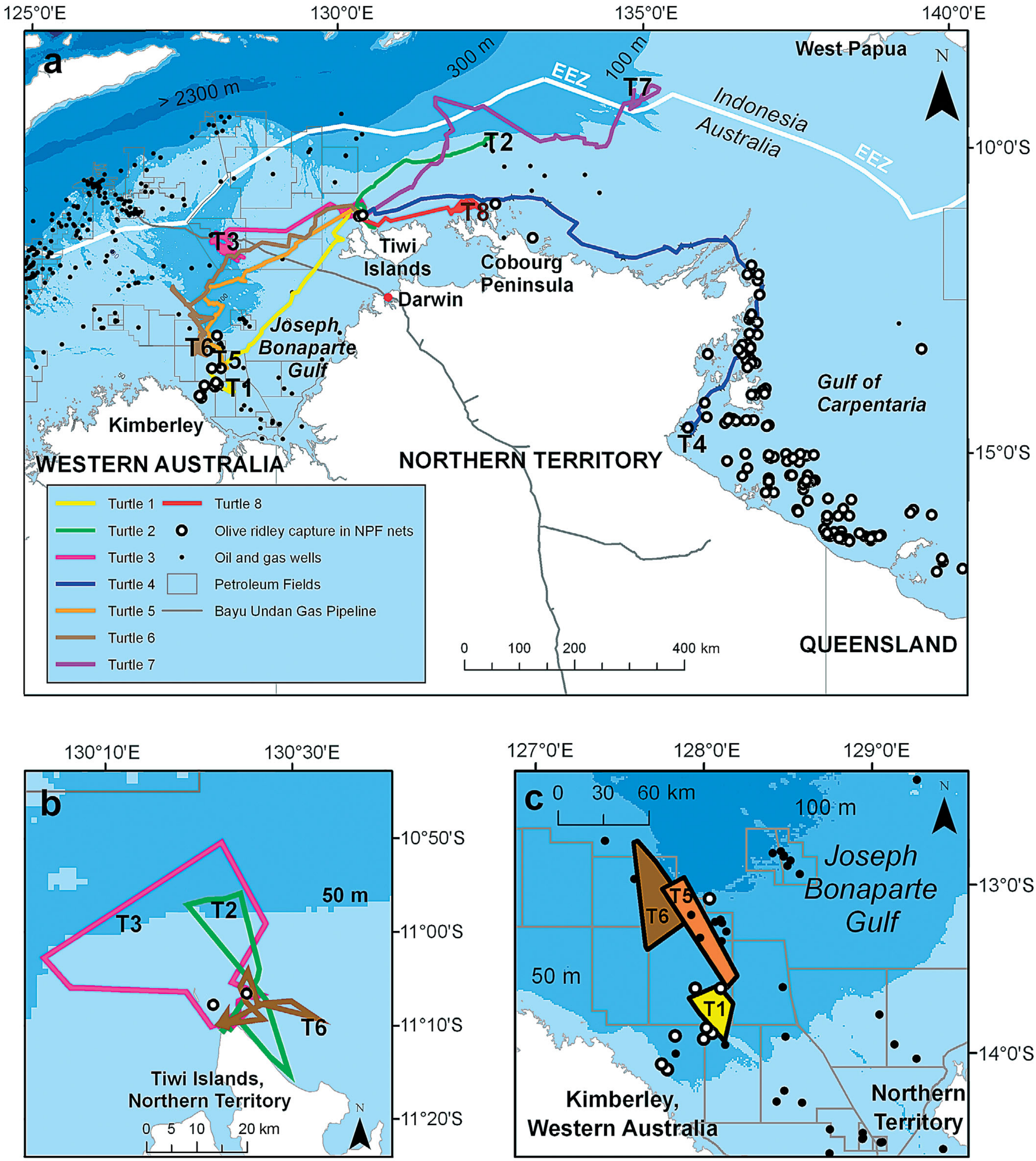

Fig. 1. *Lepidochelys olivacea*. (a) Post-nesting movements of 8 olive ridley turtles (T1 to T8). (b) Inter-nesting movements of 3 olive ridley turtles (T2, T3, T6), at Cape Van Diemen, Tiwi Islands; (c) foraging areas of 3 Turtles (T1, T5, T6), near the Kimberley coast of western Australia. EEZ: Exclusive Economic Zone. Northern Prawn Fishery (NPF) incidental captures of olive ridley turtles between 1998 and 2001 prior to the installation of Turtle Excluder Devices (TEDs) (Robins et al. 2002). Oil and gas exploration and mining downloaded from Geoscience Australia (December 2005, available at: www.ga.gov.au). Bathymetric data downloaded from Geoscience Australia (December 2005, also available at above website)

Australian waters (Limpus & Roper 1977, Haines et al. 1999, Haines & Limpus 2000, Greenland et al. 2002).

The foraging behaviour of olive ridley turtles is largely unknown in Australia. NPF bycatch records indicate various water depths (up to 60 m) used by olive ridley turtles (Robins et al. 2002). Dietary samples of olive ridley turtles from the eastern Joseph Bonaparte Gulf indicate foraging depths of less than 14 m (Conway 1994). Studies outside Australia indicate that olive ridley turtles forage in a variety of habitats, including oceanic and deep and shallow benthic habitats (Bjorndal 1997). Others describe olive ridley turtles as mostly pelagic with large unidirectional wandering movements (Luschi et al. 2003, Polovina et al. 2003, 2004, Plotkin 2003). Several satellite tracking studies have confirmed oceanic foraging behaviour for adult male, adult female and juvenile olive ridley turtles which can cover up to several thousand square kilometres (Plotkin et al. 1994, 1996, Beavers & Cassano 1996, Vasconcelos et al. 2001, Parker et al. 2003, Polovina et al. 2003, 2004). Direct sightings of sea turtles in the open ocean confirm that olive ridley turtles are the most common species in this habitat (Pitman 1990, Arenas & Hall 1992).

Migration routes and distances between nesting beaches and foraging areas are unknown for olive ridley turtles in Australia. In India (Pandav & Choudhury 1998, Shanker et al. 2003) and the eastern Pacific (Plotkin et al. 1994, 1996, Vaconcelos et al. 2001, Parker et al. 2003), olive ridley turtles have been recorded making extended post-nesting migrations. For the effective management of this endangered species in Australia, knowledge of all parts of the lifecycle is necessary, including the inter-nesting habitats, migration routes and foraging areas. The aims of this study were to: (1) gain insights into inter-nesting behaviour, (2) identify migratory routes and (3) identify foraging areas in relation to potential threats.

MATERIALS AND METHODS

We attached satellite transmitters (Platform Terminal Transmitters — PTT) to 8 olive ridley turtles at the completion of oviposition at Cape Van Diemen, on Turtle Melville Island (11° 12′ S, 130° 24′ E) in 2004 and 2005. Turtles were allowed to complete their nesting activity before being disturbed. The beach is located about 30 km north of the nearest community of Garden Point (Pirlangimpi) and about 100 km north of Darwin, Northern Territory. Each turtle was also tagged on each of the front flippers with uniquely numbered titanium tags (Limpus 1992) and measured (curved carapace length, CCL in cm: Limpus et al. 1984). The transmitters included 6 KiwiSat 101, 0.5 W (SirTrack) and 2 Cricket (Wildlife Computers) transmitters (Table 1). The KiwiSat transmitters were attached with either Powerfast® epoxy (Mitchell 1998) or a combination of fibreglass and a base of Powerfast® epoxy (Balazs et al. 1996, Polovina et al. 2003, 2004). The Cricket transmitters had a smaller base to height ratio than the KiwiSat transmitters and therefore a larger base was required to increase the surface area and the adhesion properties. A polycarbonate base plate was shaped using a mould of a carapace from the Northern Territory Museum specimen and this was secured to the carapace using epoxy and 3 surgical screws. All transmitters were switched on continuously for the first 60 d followed by various duty cycles to conserve battery power and to facilitate longer tracking periods (for individual duty cycles see Table 1). Data were collected via the Argos satellite system (Argos 1996). Argos (1996) assigns location classes (LC) to each location as an estimate of accuracy, which include LC3 (±150 m), LC2 (±350 m), LC1 (±1000 m) and LC0 (>1000 m). Field tests showed that these estimates of accuracy were close to real errors from known locations (Hays et al. 2001). Additional Location Classes (LCA and LCB) have unknown accuracy (Argos 1996).

The tracking information was automatically downloaded and sorted into fields from the Argos databank via Satellite Tracking and Analysis Tool (STAT) (Coyne & Godley 2005). Only LC3, LC2 and LC1 were used to calculate speeds and distances. Erroneous fixes were removed by STAT (Coyne & Godley 2005) if it meant swim speeds of over 5 km h^{-1} were required to reach that location (see Luschi et al. 1998). Migration routes were plotted (Fig. 1a) using additional LCs (LC0 and LCA) with the STAT angle filter set at 70° to ensure that maximum data was used for the pictorial display of the migration routes. Data were exported from STAT for further analysis and mapping. The renesting interval was determined as the number of days between a successfully laid clutch and the next nesting attempt. The foraging areas were identified as those areas where turtles showed multi-directional movement, backtracked over previous tracks or remained in relatively small areas for extended periods. Maps were produced using ArcView 9.1 Software (ESRI). Foraging areas were estimated using 95 and 50% minimum convex polygons (MCP) conducted using Biotas software (Ecological Solutions). Human-related activities such as oil and gas wells and captures of turtles from the NPF were mapped to examine overlaps with habitats used by *Lepidochelys olivacea*. The Cricket transmitters also collected information on dive behaviour for 2 turtles (Turtles 7 and 8) and transmitted the summarised data via Argos in histogram format. For the frequency of maximum depth of each dive the upper bin values were 0, 5, 10, 20, 30, 40, 50, 80, 110, 120, 150, 200, 400, 800 and 800+ m. For the frequency of the time spent at each depth, the upper bin values were 0, 5, 10, 20, 50, 100, 150, 200, 300, 400, 500, 600, 700, 800 and 800+ m. For dive duration, the upper bin values were 1, 2, 5, 10, 20, 30, 40, 50, 60, 80, 100, 120, 180 and 180+ min.

RESULTS

Transmitters remained attached for a mean of 77 d (SD = 88, range = 17 to 283, n = 8) (Table 1). Good locations (LC3, LC2 and LC1) were obtained for a mean of 55 d (SD = 38.7, range 19 to 125, n = 8).

Inter-nesting habitat

Three turtles renested at 12 (Turtle 2), 15 (Turtle 3) and 23 (Turtle 6) d (mean = 16.7, SD = 5.7) after their previous oviposition. All 3 turtles moved away from the beach immediately after nesting to areas between 17 and 37 km offshore (Fig. 1b). Turtles 2 and 3 both visited an area that had sloping bathymetry and water depths of between 45 and 55 m.

Migration

Once nesting was completed for the season, all turtles travelled between 180 and 1050 km to foraging areas (Table 2). The direction of migration routes varied among the turtles (Fig. 1a). Migration speed ranged from 0.87 to 1.54 km h^{-1} (Table 2) and time taken to reach their foraging areas ranged from 5.5 to 34 d. Turtle 4 covered more than 1000 km in 21 d before reaching her foraging area in the southwestern Gulf of Carpentaria. All turtles remained within 240 km of land during their migration (Table 3). Turtle 4 kept close to the coast and was always within 50 km of land. The migration paths of all turtles were relatively straight, except for Turtle 4, whose path followed the coast. Only Turtle 7 left the continental shelf during migration, although Turtle 2's track indicated that she was also heading off the continental shelf before her PTT stopped transmitting. No turtles travelled to the coastal waters or continental shelf of a neighbouring country.

Several of the turtles may have foraged during their migration phase before they reached their final foraging grounds. Turtle 5 slowed down on several occasions and deviated from a direct route on several occasions. Turtle 4 also had periods of slow movement, which may have indicated periods of foraging or rest during her long distance migration. The dive data from Turtles 7 and 8 were checked against bathymetry data for the region and indicated that both turtles dived to or near the substrate regularly. Turtle 7 had the largest data set, and during her migration period 70% of her dives (greater than 5 m) were between depths of 40 and 110 m (Fig. 2a). During a period when she left the continental shelf she made dives to depths of between 150 and 200 m (Fig. 2a). She spent 72% of her total time at depths between 50 and 150 m and 8% of her time at depths between 150 and 200 m (Fig. 2c). During the migration period 50% of her dive durations (dives > 1 min) were between 30 and 80 min (Fig. 2e). Maximum dive durations were between 120 and 180 min. Turtle 8 made a short inshore migration and remained in coastal waters, where 86% of her dives (greater than 5 m) were to depths of between 30 and 50 m with no

Table 1. *Lepidochelys olivacea.* Satellite attachment information for 8 olive ridley turtles tagged at Turtle Melville Island in 2004 and 2005. CCL: curved carapace length; PTT: Platform Terminal Transmitter. Distance: total distance travelled. A: first 60 d, on continuously; next 30 d, on for 12 h and off for 30 h; remainder, on for 12 h and off for 72 h for their remaining battery power. B: first 60 d, on continuously; for remaining time, on for 8 h and off for 4 h every second day. Data collected included location (L) and depth data (D)

Turtle ID	CCL (cm)	PTT type and manufacturer	Attachment method	Duty cycle & type of data collected	Date of deployment	Date of last good location	Tracked days[a] (n)	Transmission days	Distance (km)	Good locations (n)
1	75.2	Kiwi Sat, SirTrack	Epoxy	A, L	19 Apr 04	8 May 04	19	19	485	61
2	72.4	Kiwi Sat, SirTrack	Epoxy	A, L	19 Apr 04	17 May 04	28	28	427	47
3	71.1	Kiwi Sat, SirTrack	Epoxy and fibreglass	A, L	20 Apr 04	21 Jun 04	62	62	611	80
4	66.4	Kiwi Sat, SirTrack	Epoxy	A, L	21 Apr 04	24 Aug 04	125[b]	283	1358	69
5	70.8	Kiwi Sat, SirTrack	Epoxy and fibreglass	A, L	21 Apr 04	31 May 04	40	40	608	100
6	71.0	Kiwi Sat, SirTrack	Epoxy	A, L	1 Jun 05	25 Aug 05	86	91	812	77
7	71.8	Cricket, Wildlife Computers	Epoxy and medical screws	B, L & D	19 Jul 05	30 Sep 05	73	73		38
8	67.2	Cricket, Wildlife Computers	Epoxy and stainless steel screws	B, L & D	21 Jul 05	7 Aug 05	10	17	189	10

[a]Location classes (LC) 1, 2 or 3
[b]Intermittent transmissions indicated that the PTT remained on Turtle 4 for a further 140 d but were of poor quality and are not included in analysis

Table 2. *Lepidochelys olivacea*. Summary of migration duration, distances and speeds for 8 olive ridley turtles tagged on Turtle Melville Island in 2004 and 2005. Min. dist.: minimum distance travelled during migration using good quality locations only

Turtle ID	Migration duration (d)	Min. dist. (km)	Min. straight-line distance (km)	Mean (SD) migration speed (km h^{-1})
1	12	401	365	1.54 (0.43)
2	>15	>331	>208	1.07 (0.55)
3	5.5	236	230	1.79 (0.02)
4	45	1130	1050	0.94 (0.22)
5	34	569	354	0.87 (0.62)
6	52	519	351	1.13 (0.96)
7	59	643	553	0.62 (0.53)
8	>8	189	165	0.70 (0.42)

dives greater than 80 m (Fig. 2a). She spent the most time at depths between 0 and 50 m (Fig. 2d) and had dive durations of less than 80 min (Fig. 2f).

Foraging locations, habitat and behaviour

Data for 7 turtles were sufficient to indicate 5 geographically distinct foraging areas, 3 of which were ecologically different (Fig. 1a). The 5 geographically distinct areas included the western edge of the Gulf of Carpentaria, Cobourg Peninsula, edge of the Sahul Shelf and the northern and southern Joseph Bonaparte Gulf (Fig. 1a). The 3 ecologically distinct areas comprised shallow nearshore, continental shelf and continental slope habitats. Four turtles used foraging areas in the Joseph Bonaparte Gulf (continental shelf). Turtle 1 (2004), Turtle 5 (2004) and Turtle 6 (2005) used foraging locations in the southern part of the Joseph Bonaparte Gulf located southwest of Turtle Melville Island (Fig. 1c). The foraging areas of these 3 turtles were close together (final locations only 11 km apart) despite being over 350 km from the nesting beach. Turtle 3 used the northern and seaward part of the Joseph Bonaparte Gulf (continental shelf) 230 km directly west of her nesting beach. Turtles 2 and 7 travelled to the continental slope northeast of the nesting beach. Turtles 4 and 8 both used shallow nearshore habitat, 1050 and 165 km from their nesting beach, respectively. Only 3 turtles produced sufficient data to investigate foraging areas using 95% Minimum Convex Polygons. They included 138 km^2 (Turtle 4 over 140 d), 1182 km^2 (Turtle 3, 39 d) and 1260 km^2 (Turtle 6, 34 d) (Table 3, Fig. 1c).

Similar to the dive behaviour recorded during migrations, dive and bathymetry data indicated that both Turtles 7 and 8 foraged at or near the substrate. While foraging on the continental slope during a 14 d period, Turtle 7 made 87% of her dives (greater than 5 m) to depths of between 30 and 110 m (Fig. 2a), spent 54% of her time at depths of between 20 and 50 m (Fig. 2c) and 66% of her dives (dives > 1 min) were between 20 and 50 min (Fig. 2e). Turtle 8 foraged in coastal inshore habitat and made 95% of her dives between the depth ranges of 5 to 30 m (Fig. 2d) and spent 98% of her time between 10 and 50 m (Fig. 6f). Maximum dive durations were in the range of 120 to 180 min with 59% in the range of 40 to 80 min.

Table 3. *Lepidochelys olivacea*. Foraging areas and foraging habitat used by 8 olive ridley turtles tagged on Turtle Melville Island in 2004 and 2005. Time in foraging area: days spent in foraging area before cessation of transmissions; Max. dist. migration: maximum distance that a migration location occurred from land; Max. dist. foraging: maximum distance that a foraging location occurred from land. MCP: minimum convex polygons; –: value could not be calculated

Turtle ID	Location of foraging areas	Time in foraging area (d)	No. locations in foraging area (LC1, 2 or 3)	Depth of foraging area (m)	Max. dist. migration (km)	Max. dist. foraging (km)	Foraging range (km^2)	MCP
1	Joseph Bonaparte Gulf	8	5	50–60	133	77	–	–
2	NE of Turtle Melville Island (shelf-slope)	–	–	–	132	–	–	–
3	Joseph Bonaparte Gulf	39	37	40–50	230	230	1182	469
4	Western coast of Gulf of Carpentaria	238[a]	15	<20	49	25	138	20
5	Joseph Bonaparte Gulf	4	10	50–60	208	91	–	–
6	Joseph Bonaparte Gulf	34	35	50–60	209	112	1260	192
7	NE of Turtle Melville Island (shelf-slope)	14	14	85–150	244	237	–	–
8	Cobourg Peninsula	7	7	5–35	37	28	–	–

[a]Last 140 d of transmissions produced poor quality fixes but were used to indicate time in the area

DISCUSSION

The satellite tags transmitted between 19 and 283 d, which was less than the expected battery life for all but one transmitter. There could be several reasons for this: (1) the transmitters detached from the carapace, (2) the transmitters malfunctioned, (3) the batteries failed, (4) death of the turtle, (5) the salt-water switches became fouled, or (6) the antenna was damaged. The detachment of the transmitters is the most likely scenario, which we surmised from the abrupt cessation of transmissions and the return of Turtle 1 to the same nesting

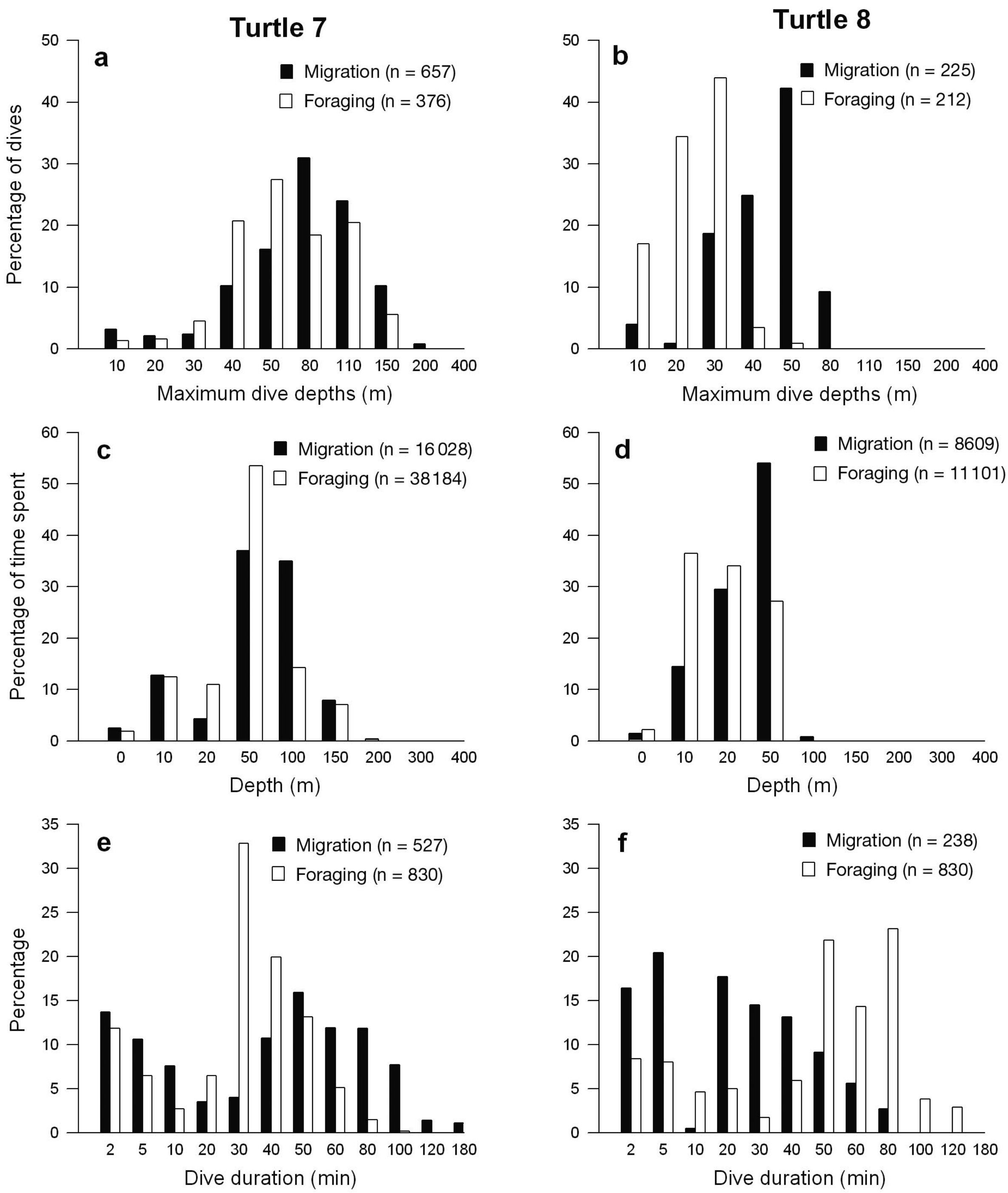

Fig. 2. *Lepidochelys olivacea*. Frequency histograms of diving behaviour for 2 olive ridley turtles. (a,b) Maximum dive depths (for dives >5 m); (c,d) time spent in each depth range (for dives >1 m); (e,f) dive durations (>1 min)

beach in April 2005 with no transmitter or trace of adhesive on the carapace. Of the 3 transmitters that stayed attached the longest, 2 used epoxy only (see Table 1). Many tracking projects have used similar methods on other species with minimal problems: green turtles (Balazs et al. 1996, Papi et al. 1997, Luschi et al. 1998, Hays et al. 2003, Kennett et al. 2004), loggerhead turtles (Mitchell 1998, Polovina et al. 2003, 2004), olive ridley turtles (Plotkin et al. 1996, Polovina et al. 2003, 2004) and hawksbill turtles (S.D.W. unpubl. data). The low levels of keratin in olive ridleys compared to other hard-shell turtles could reduce the length of attachment time compared to other species. In the Pacific, transmitters attached to 2 olive ridley turtles using fibreglass remained functional for 22 and 95 d (Polovina et al. 2003), further supporting the notion that the early loss of transmissions could be species related.

Inter-nesting habitat

The renesting intervals reported here (12, 15 and 23 d) consisted of 2 intervals that were shorter than the lowest interval reported for mass nesting events (arribadas) in populations outside of Australia (17 to 45 d, Miller 1997), but similar to those reported for solitary nesters (14 d, Pritchard 1969 in Plotkin 2003). Within-season nesting fidelity was shown by Turtles 2, 3 and 6 and remigration fidelity was shown by Turtle 1, who returned to nest on Cape Van Diemen in 2005. This contradicts Kalb (1999 in Plotkin 2003), who suggested that solitary nesting olive ridley turtles show weak site fidelity. Turtles used inter-nesting habitat to a distance of 37 km from the nesting beach, which is an area also used by trawlers of the NPF. Although the NPF is required to have TEDs installed on their nets, the impact of non-lethal interactions on the behaviour of marine turtles in their inter-nesting inshore habitat is unknown. Potential negative interactions between trawlers and inter-nesting sea turtles suggest that trawling should be restricted to areas outside the inter-nesting habitat around significant nesting beaches of endangered sea turtles.

Migration

The sample of 8 turtles from this study showed migration distances of between 180 and 1100 km. The maximum migration distance in this study was similar to the 1500 km journey of an olive ridley turtle tagged at Orissa in India and captured in eastern Sri Lanka (Pandav & Choudhury 1998). However, these distances are short in comparison to movements of non-nesting olive ridley turtles tagged in the Pacific Ocean (2691 km, Beavers & Cassano 1996; 7282 km, Polovina et al. 2004). All turtles made relatively direct movements to foraging areas with observed distances only slightly longer than minimum straight-line distances (Table 2). This indicates that a foraging location was targeted and differs from the wandering foraging movements observed for Pacific olive ridley turtles (Plotkin 2003). All turtles remained on or near the continental shelf in the present study, which also differs from the idea that olive ridley turtles spend most of their non-breeding time in oceanic waters, quickly migrating back to oceanic waters once breeding is complete (Byles & Plotkin 1994, Plotkin 2003).

Foraging locations, habitat and behaviour

This study indicated 5 geographic foraging areas and 3 ecological feeding habitats. The areas included one in the Gulf of Carpentaria, two in the Joseph Bonaparte Gulf, one near Cobourg Peninsula and two on the shelf-edge north of the Northern Territory. Habitats included shallow coastal (Turtles 4 and 8), continental shelf (Turtles 1, 3, 5 and 6) and continental slope (Turtles 2 and 7). No turtles visited the eastern Joseph Bonaparte Gulf (less than 200 km to the south), which was identified as an important feeding area after a stranding event (Guinea & Chatto 1992). Two of the foraging locations, one in the northern Joseph Bonaparte Gulf and the other on the shelf slope between Australia and West Papua, were used by *Lepidochelys olivacea* during a simultaneous study of dive behaviour in olive ridley turtles tagged in northeastern Northern Territory (McMahon et al. 2007). Both tracking studies, supported by captures in the NPF, indicate that the continental shelf is an important foraging habitat for olive ridley turtles in northern Australia, which contrasts the previously reported oceanic foraging behaviour by other populations (Luschi et al. 2003, Plotkin 2003, Polovina et al. 2003, 2004). Fidelity to specific foraging areas over long periods was shown by Turtle 4, which spent 40 wk in an area less than 150 km^2. Shallow feeding behaviour by olive ridley turtles, previously identified in the Joseph Bonaparte Gulf in 1991 (Guinea & Chatto 1992, Conway 1994), was supported by the shallow water foraging locations of Turtles 4 and 8 in the present study.

Aggregated feeding behaviour by olive ridley turtles was indicated by the overlapping foraging locations of 3 turtles (tagged in 2004 and 2005) together with the NPF capture data (1998 to 2000) (Robins et al. 2002) (Fig. 1a,c). This relatively small area of activity over several years indicates that food resources or suitable habitat may be isolated or patchy but predictable. These localised and aggregated foraging records differ from the wide-ranging foraging records in the Pacific (Byles & Plotkin 1994, Plotkin 2003, Polovina et al. 2003, 2004).

It is hypothesized that Turtles 7 and 8 exhibited foraging behaviour during their migration and foraging phases because of the high percentages of dives to the substrate together with the extended periods of time at these depths. This is similar to findings by McMahon et al. (2007) that 4 turtles frequently dived to the substrate during migrations and foraging periods. Diving behaviour of oceanic olive ridley turtles in the Pacific had similar maximum dive ranges and over 40% of their time below 40 m (Polovina et al. 2003, 2004). Based on bathymetric data, the depth of foraging areas ranged from less than 20 up to 150 m. It is unknown if the turtles in this study were exclusively benthic feeders like those reported by Conway (1994) or fed on a combination of surface and benthic prey items like those reported in the Pacific Ocean (Honolulu Laboratory unpubl. data, cited in NMFS in Polovina et al. 2004). They may be opportunistic foragers and take advantage of sporadic events like the large congregation of olive ridley turtles found feeding in a squid schooling area (Robins et al. 2002).

Potential impacts

The migration routes and foraging areas of these turtles overlapped considerably with areas of prawn trawling and mining activity in northern Australia. TEDs have been mandatory on all NPF vessels since 2000; therefore most captured turtles should be released alive. However, the non-lethal impacts of capture and release and damage to benthic foraging habitat have not been documented. Oil and gas exploration and mining is active in northwestern Australia and overlaps with foraging areas in the Joseph Bonaparte Gulf (Fig. 1a). The impacts of exploratory research and increased shipping activity on *Lepidochelys olicacea* are unknown.

In conclusion, this study showed that turtles from a single nesting beach (1) used geographically and ecologically distinct foraging areas, (2) were mainly confined to the continental shelf, (3) used foraging areas that may have predictable benthic food sources, (4) used areas during migration and foraging that overlapped with trawling and mining activities and (5) exhibited renesting and remigration fidelity to nesting beaches.

Acknowledgements. All procedures were approved by the Animal Ethics Committee at Charles Darwin University and were conducted under permits from Parks and Wildlife NT and the Tiwi Land Council. This project was funded in part by the Natural Heritage Trust, Australian Government and the Tony and Lisette Lewis Foundation. We thank T. Dore (Charles Darwin University) and D. White (WWF-Australia) for submitting the first application for funding. K. Cook (WWF-Australia) assisted in the field and produced the final maps. A. Lauder, (Coastcare), K. Hadden (Tiwi Land Council), L. Gregory, K. Cook (WWF Australia), G. Whiting and the students of the Pularumpi School assisted with the attachment of transmitters. C. Kalipa and K. Hadden (Tiwi Land Council) ensured that liaison within the community was properly conducted and the correct permits were in place. The Northern Prawn Fishery data were supplied by C. Robins (Australian Fisheries Management Authority). Paul Horner at the NT Museum provided access to olive ridley specimens. Educational activities were conducted by Pularumpi School and Coastare NT. Promotion of the project was assisted by WWF-Australia, IOSEA, and Channel 7 Australia. The manuscript was improved by comments by A. Koch, K. Hadden and D. White.

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Editorial responsibility: Rory Wilson, Swansea, UK

Submitted: May 15, 2006; Accepted: November 23, 2006
Proofs received from author(s): January 3, 2007