A BIOLOGICAL REVIEW OF AUSTRALIAN MARINE TURTLES.

4. OLIVE RIDLEY TURTLE *Lepidochelys olivacea* (Eschscholtz)

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Cover photographs: Clockwise from top left: Nesting female *Lepidochelys olivacea* at Mapoon, Queensland; Flinders Beach north of Pennyfather River, western Cape York Peninsula; Hatchling from Tiwi Island, Northern Territory; Adult male *Lepidochelys olivacea* among trawl bycatch, Northern Prawn Fishery, before Turtle Excluder Devices (TEDs). *Photograph from Bureau of Rural Sciences NPF trawl bycatch monitoring project.*

A biological review of Australian marine turtle species. 4. Olive Ridley turtle Lepidochelys olivacea (Eschscholtz)

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PREFACE

This review of the loggerhead turtle provides the first comprehensive collation of biological data for the species. While peer reviewed scientific publications are the most significant source of information for the species, there is a large body of additional information available from many other sources within Australia. In particular, I have drawn together data contained in many unpublished reports on file in various government and non-government agencies. In addition, relevant information has been obtained from newspaper reports and from books and journals describing the early exploration and natural history of Australia. The review provides a comprehensive summary of information available up to August 2004.

To provide a more comprehensive summary of available information, previously unpublished data drawn from the Queensland Environmental Protection Agency (EPA) Turtle Conservation Project database have been summarised and included. These data are a collation of the results of private research undertaken by myself since 1968 and turtle research undertaken by EPA staff and trained volunteers within foraging and nesting populations in Queensland and adjacent areas within Australia and neighbouring countries.

My understanding of sea turtle biology has been greatly enhanced through collaborative studies with Dr John Parmenter, Dr Craig Moritz, Dr David Owens and Dr Joan Whittier and their respective post-graduate students.

Many folks have assisted in the preparation of this review both directly and indirectly. I am particularly indebted to the assistance and support that I received from Queensland Parks and Wildlife Service staff, in particular Dr Jeff Miller and Duncan Limpus and others who worked in our field studies: Barry Lyon, David Walters, Valonna Baker, Annette Fleay, Phillip Read, Emma Gyuris, Darryl Reimer, Mark Deacon, Ian Bell, Cathy Gatley and John Meech. Keith Morris, Dr Bob Prince and Kelly Pendoley provided guidance regarding turtles in Western Australia. Dr Mick Guinea, Dr Scott Whiting, Ray Chatto and Dr Rod Kennett assisted with information regarding turtles in the Northern Territory.

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A BIOLOGICAL REVIEW OF AUSTRALIAN MARINE TURTLES

OLIVE RIDLEY TURTLE, *Lepidochelys olivacea* (Eschscholtz)

1. THE SPECIES

1.1 TAXONOMY

Olive Ridley turtle, *Lepidochelys olivacea*.

CLASS:	REPTILIA
ORDER:	TESTUDINES
FAMILY:	CHELONIIDAE
SPECIES:	*Lepidochelys olivacea* (Eschscholtz, 1829)

Lepidochelys olivacea is one of two extant species for the genus (Figure 1), the other being *Lepidochelys kempii.* There are no valid subspecies currently recognised for *L. olivacea* (Pritchard and Trebbau, 1984).

1a. Large immature from Cairns inlet, Queensland

1b. Nesting female at Mapoon, Queensland.

1c. Head of adult female, caught foraging off Townsville, Queensland.

1d. Hatchling from Tiwi Island, Northern Territory.

Figure 1. *Lepidochelys olivacea* from Australia.

1.2 GLOBAL DISTRIBUTION

The genus *Lepidochelys* is represented by two species. *Lepidochelys olivacea* has a worldwide circumtropical distribution, including northern Australia (Figure 2. Marquez, 1990; Cogger and Lindner, 1969). *Lepidochelys kempii* is restricted to the Gulf of Mexico and north Atlantic basin. Genetic studies of *Lepidochelys* and other marine turtle species on the global scale indicate limited female-mediated interbreeding between the major breeding aggregations (Bowen *et al.* 1998).

The only remaining very large nesting populations with over 100,000 nesting females annually are in Orissa on the east coast of India (Figure 2) and the eastern Pacific coast of Central America in Mexico and Costa Rica (Marquez, 1990; Dash and Kar, 1990; Reichart, 1993). The once large nesting populations of *L. olivacea* that occurred in Peninsula Malaysia and Thailand have been decimated through long term, over-harvest of their eggs (Limpus, 1997). The species nests in low numbers at many sites in Indonesia and is only rarely encountered nesting in the Republic of the Philippines or Papua New Guinea (Figure 2). There is only sporadic *L. olivacea* nesting in the western Pacific (Geermans and Farago, 1993). While the Australian *L. olivacea* nesting distribution and population size remains to be fully evaluated (Chatto, 1998; Limpus *et al.* 2008), it appears to be the largest breeding population remaining in the southeast Asia–western Pacific region (Figure 2).

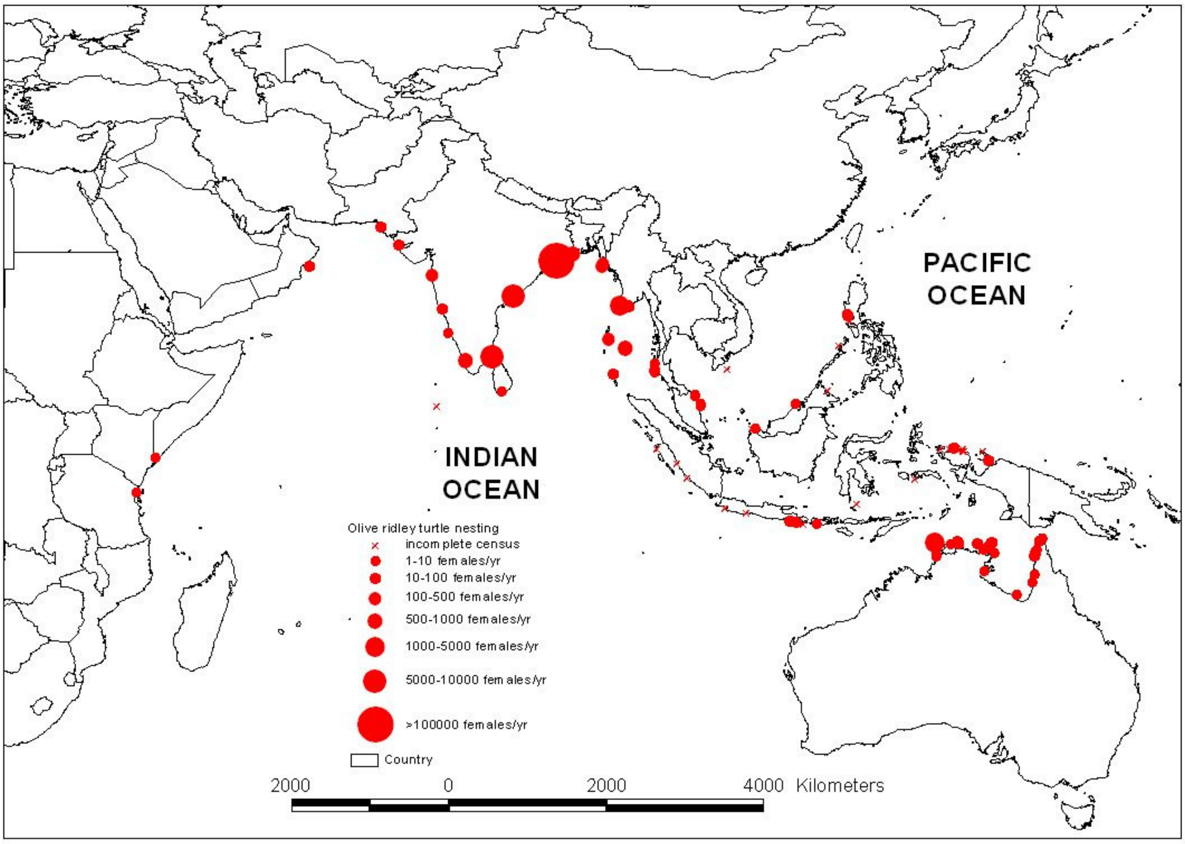

Figure 2. Distribution of *Lepidochelys olivacea* breeding sites in the Indian Ocean – Western Pacific.

1.3 IDENTIFICATION

The carapace is covered with large keratinised scutes including six or more pairs of costal scutes. The presence of more than 5 costal scutes and inframarginal pores is diagnostic for the species (Cogger, 1992; Limpus, 1992) (Figure 3).

Figure 3. Diagnostic features for identifying *Lepidochelys olivacea*.

Lepidochelys olivacea eggs are smaller than other species of sea turtle egg (average egg diameter = 3.7 cm), are of a similar size to *Eretmochelys* eggs and the clutches rarely contain numerous yolkless eggs (Limpus *et al.* 1983; Limpus and Preece, 1992). When ashore for nesting, females move with an alternate (= quadrupedal) gait. The narrow beach-crawl tracks of nesting females are difficult to distinguish from those of *Eretmochelys imbricata*. When covering the nest, females compact the sand by alternately slamming each side of the body on the sand (Whiting, 1997) which is a behavioural characteristic unique to this genus.

The morphology of *L. olivacea* has been described by Wyneken (2001).

2. BIOLOGY OF THE OLIVE RIDLEY TURTLE, *Lepidochelys olivacea* (Eschscholtz), IN AUSTRALIA.

Where possible, data were derived from studies of *L. olivacea* populations within Australia. However, where relevant data were not available, information from studies on *L. olivacea* stocks elsewhere are presented (Marquez, 1990; Dash and Kar, 1990; Reichart, 1993) or extrapolated from appropriate studies with other species of marine turtle.

2.1 GENETIC STATUS of STOCK

Tissue samples were collected from *L. olivacea* that breed in northwestern Arnhem Land and analysed within global genetics studies of *L. olivacea* populations. These studies indicated that the Australian breeding population is genetically distinct from the *L. olivacea* breeding in Malaysia, India and the eastern Pacific (Bowen *et al.* 1998; Dutton *et al.* 2002). The Australian breeding population can therefore be regarded as a separate management unit, independent of larger nesting aggregations occurring in India, Mexico and Costa Rica. The small breeding populations in Indonesia and Papua New Guinea have not been included in the global analysis of *L. olivacea* stock identification. Until there are data to the contrary, the Australian nesting populations will be discussed as a single breeding unit.

2.2 AUSTRALIAN BREEDING UNIT

2.2.1 ROOKERIES and POPULATION SIZE

The size of the Australian nesting population, when pooled across its many rookeries (Cogger and Lindner, 1969; Guinea, 1990; Limpus and Preece, 1992; Chatto, 1998; Limpus *et al*. 2008), appears to be an isolated, moderately sized population when compared with the global populations (Marquez, 1990; Dash and Kar, 1990; Reichart, 1993). The Australian *L. olivacea* do not appear to form high density synchronised breeding aggregations (arribadas) that typify the species nesting behaviour in the eastern Pacific and northern Indian Ocean basins. Historically, no major breeding concentration has been recorded in Australia.

There is no evidence to suggest that the current modest nesting numbers in Australia are the remnant of a population that has declined substantially within historical times.

Northern Territory

The nesting density of *L. olivacea* in the Northern Territory has not been quantified but is expected to be in the order of a few thousand females annually. The highest density of nesting for the species in Australia, with hundreds of nesting females annually per rookery, has been recorded on islands along the Arnhem Land coast (Figure 2). These islands include: English Company Islands, Wessel Islands and Crocodile Islands of north-eastern Arnhem Land and Grant Island, McCluer Island Group, Coburg Peninsula, Melville Island (Figure 4a) and Bathurst Island off north-western Arnhem Land (Cogger and Lindner, 1969; Guinea, 1990; Limpus and Preece, 1992; Chatto, 1998; Limpus *et al*. 2008).

Low density nesting has also been recorded at a limited number of sites over recent decades in western Northern Territory (Whiting, 1997) and in eastern Arnhem Land (Gow, 1981; Chatto, 1998; Limpus *et al*. 2008). The *L. olivacea* nesting beaches of Coburg Peninsula are protected habitat within the Gurig National Park. The Dhimurru Indigenous Protected Area encompasses low-density rookeries.

Queensland

Low-density nesting occurs along the northwestern coast of Cape York Peninsula between Weipa and Bamaga (Limpus and Roper, 1977; Limpus *et al.* 1983; Dr J. Miller, unpublished data, April 2002) (Figure 4b). An isolated nesting was recorded for the Wellesley Islands (Bustard, 1971). There are no records of *L. olivacea* nesting from the east coast of Australia even though vitellogenic adult females have been captured in foraging areas off Townsville within the Great Barrier Reef (GBR).

No census has been made of the size of the nesting population in Queensland. No Queensland rookeries are managed within National Parks or similar protected habitat.

4a. Imula Beach, Melville Island, Northern Territory.

4b. Flinders Beach north of Pennyfather River, western Cape York Peninsula.

Figure 4. *Lepidochelys olivacea* nesting habitat in northern Australia.

Other states

There are no records of *L. olivacea* nesting from Western Australia, New South Wales or the more southerly states.

2.2.2 FIDELITY TO NESTING SITES

No data are available from Australia; no dedicated tagging studies have been conducted on the nesting populations. It is presumed that the species here will show similar fidelity to traditional nesting beaches as elsewhere. Females nesting in arribadas (= aggregated synchronised mass nesting populations) display strong nesting beach fidelity while solitary nesting females display weak nesting beach fidelity (Plotkin, 2003).

2.2.3 MIGRATION

Lepidochelys olivacea in other countries have been recorded making long distance breeding migrations (Cornelius and Robinson, 1983; Marquez, 1990; Plotkin, 2003). Satellite telemetry studies in progress in the Northern Territory (Whiting, 2004) have confirmed that the northern Australian breeding *L. olivacea* undertake post-breeding migrations to disperse to widely scattered foraging areas within the Australian continental shelf.

2.2.4 BREEDING SEASON

Nesting in Northern Australia appears to occur all year with an early dry season peak (April to June) (Cogger and Lindner, 1969; Guinea, 1990; Limpus and Preece, 1992; Chatto, 1998). Hatchlings can be expected to emerge from nests approximately two months after oviposition.

2.2.5 BREEDING ADULTS

Adults and large immature turtles are uniform grey to olive-grey dorsally and whitish ventrally (Figure 1). The carapace is approximately heart shaped with broad marginal scales. Australian nesting female size is summarised in Table 1.

2.2.6 BREEDING CYCLES

Breeding cycles have not been described from the Australian nesting population. Breeding cycles from overseas populations are summarised in Table 1.

Table 1. Size of breeding adult *Lepidochelys olivacea* in northern Australia and their reproductive cycles.

	Measurement				References
	Mean	SD	Range	n	
Curved carapace length (cm)					
Female Crab Island, Qld	71.0	–	71.0	1	Limpus, Parmenter, Baker & Fleay, 1983
Greenhill Island, NT	67.5	1.71	65.5–68.6	3	Hope & Smit, 1998
Bare Sand Is, NT	69.8	–	69.8	1	Whiting, 1997
Curved carapace width (cm)					
Female Greenhill Island, NT	68.6	3.58	66.5–72.7	3	Hope & Smit, 1998
Bare Sand Is, NT	69.3	–	69.3	1	Whiting, 1997
Weight (g)					
Bare Sand Is, NT	41.0	–	41.0	1	Whiting, 1997
Renesting Interval (days)					
Female Australia	No records				
Overseas	Variable				
• Solitary nesters	14d	–	–	–	Plotkin, 2003
• Arribada nesters	~28d	–	–	–	Plotkin, 2003
Remigration interval (years)					
Female Australia	No records				
Overseas	1–3	–	–	–	Hirth, 1980

2.2.7 EGGS

The eggs are cleidoic, white and approximately spherical. For successful incubation they must be laid in 25 °C –33 °C, well ventilated, low salinity, high humidity nest substrate not subjected to flooding (Miller, 1985). There is no parental care of the eggs or hatchlings. As with other species of marine turtles, embryonic death will occur with rotation of the eggs during the first quarter of the incubation period following cessation of embryonic diapause (Limpus *et al.* 1979; Parmenter, 1980; Chan *et al.* 1985).

The available data on egg and nest dimensions and incubation period are summarised in Table 2. *L. olivacea* eggs are among the smallest for Australian marine turtles and are laid in very shallow nests, compared to other species.

Table 2. Measurements of *Lepidochelys olivacea* eggs, nests and incubation periods from Northern Australia.

		Measurement				References
		Mean	**SD**	**range**	**n**	
Clutches per season						
	Australia	Not recorded				
	Overseas	2	–	–	–	Plotkin, 2003
Eggs per clutch						
	Crab Island, Qld	109.0	–	109	1	Limpus, Parmenter, Baker & Fleay, 1983
	Coburg Pen, NT	108.0	–	50–147	6	Cogger & Lindner, 1969
	McCluer Group, NT	103.4	22.8	47–143	30	Limpus & Preece, 1992
	Sth Arafura Sea, NT	101.5	19.1	–	7	Guinea, 1990
	Greenhill Island, NT	113.7	31.8	77–133	3	Hope & Smit, 1998
	Bare Sand Is, NT	108.0	–	108	1	Whiting, 1997
Yolkless eggs per clutch						
		~nil				All studies
Egg diameter (cm)						
	Crab Island, Qld	3.68	0.04	3.60–3.75	10	Limpus, Parmenter, Baker & Fleay, 1983
	Coburg Pen, NT	3.88	–	3.85–4.10	–	Cogger & Lindner, 1969
	McCluer Group, NT	3.94	0.02	3.91–3.97	3	Limpus & Preece, 1992
	Sth Arafura Sea, NT	3.67	1.50	–	23	Guinea, 1990
	Bare Sand Is, NT	3.81	0.07	3.71–3.91	10	Whiting, 1997
Egg weight (g)						
	Crab Island, Qld	37.7	0.75	36.5–38.5	10	Limpus, Parmenter, Baker & Fleay, 1983
	Sth Arafura Sea, NT	26.1	2.90	–	23	Guinea, 1990
	Bare Sand Is, NT	29.5	1.27	28–32	10	Whiting, 1997
Nest depth (cm)						
Top	Crab Island, Qld	26.0	–	26.0	1	Limpus, Parmenter, Baker & Fleay, 1983
	Sth Arafura Sea	29.3	4.00	–	7	Guinea, 1990
	Bare Sand Is, NT	35.0	–	35.0	1	Whiting, 1997
Bottom	Crab Island, Qld	38.0	–	38.0	1	Limpus, Parmenter, Baker & Fleay, 1983
	McCluer Group, NT	44.6	5.49	36–60	27	Limpus & Preece, 1992
	Sth Arafura Sea	49.1	3.70	–	7	Guinea, 1990
	Bare Sand Is, NT	46.0	–	46.0	1	Whiting, 1997
Incubation period to emergence (d)						
	Coburg Pen., NT	50	–	48–52	4	Cogger and Lindner, 1969
	Bare Sand Is, NT	53	–	53	1	Whiting, 1997

2.2.8 HATCHLINGS

Lepidochelys olivacea hatchlings are black–brown dorsally and ventrally, with slight ridges on the costal and vertebral scutes (Figure 1d). *L. olivacea* hatchlings are among the smallest marine turtle hatchlings in Australia (Table 3).

The species probably functions similarly to the other marine turtle species, with the hatchling being imprinted to the earth's magnetic field at the nesting beach (Lohmann, 1991). The hatchling may be imprinted to the smell of the sand during incubation or the water that it first contacts after leaving the nest (Grassman *et al.* 1984). This age class does not feed or sleep while crossing the beach or while swimming to deep offshore water. The hatchling phase is defined to be completed when feeding from external food resources commences.

The duration of the hatchling life history phase will be a few days.

Table 3. Measurements of *Lepidochelys olivacea* hatchlings from Northern Australia.

		Measurement				References
		Mean	**SD**	**Range**	**n**	
Straight carapace length (cm)						
Northern Territory	Coburg Peninsula	–	–	4.20–4.60		Cogger & Lindner, 1969
	McCluer Group	4.12	0.12	3.80–4.42	41	Limpus & Preece, 1992
	Sth Arafura Sea	4.10	1.90	–	19	Guinea, 1990
	Groote Eylandt	4.11	1.51	3.67–4.33	8	Gow, 1981
	Bare Sand Is	4.11	0.174	3.82–4.35	6	Whiting, 1997
Weight (g)						
Northern Territory	Sth Arafura Sea	15.30	2.00	–	19	Guinea, 1990
	Bare Sand Is	15.30	0.94	14.0–17.0	6	Whiting, 1997

2.2.9 EGG and HATCHLING SURVIVORSHIP

There is a paucity of data for egg incubation success and hatchling survivorship (Table 4).

Marine turtle clutches are subject to intense predation by feral pigs, dogs and varanids on beaches of northwestern Cape York Peninsula, (Limpus *et al.* 1993, 2000; C. Limpus *et al.* 2004). While the nesting in this region is primarily by flatback turtles, *Natator depressus,* low density *L. olivacea* clutches are laid on the same beaches and both species are subjected to high rates of egg predation. Almost the entire *L. olivacea* nesting population for Queensland occurs in this area of intense egg predation.

A similar situation exists in northwestern Northern Territory. While Melville Island supports the largest nesting population of *L. olivacea* in Australia, there is major albeit unquantified, predation of eggs by dogs on these beaches (Chatto, 2004). Baiting is being evaluated as a means of reducing dog predation of eggs on Melville Island (Chatto, 2004).

Predators of hatchlings during the beach crossing include crocodile, dog, crab and bird (Limpus and Preece, 1992; Limpus *et al.* 2004).

Survivorship of hatchlings on the beach during the crossing from nest to sea has not been quantified.

Survivorship of hatchlings in the water while crossing from the beach to deep water has not been quantified.

Table 4. Incubation success for *Lepidochelys olivacea* clutches from Northern Australia.

		Measurement				References
		Mean	SD	Range	n	
Success of incubation and emergence of hatchlings onto the beach surface from natural clutches which produced hatchlings						
NT	McCluer Group	84.4%	–	–	30	Limpus & Preece, 1992
	Sth Arafura Sea	81.0%	6.6	–	4	Guinea, 1990
	Bare Sand Is	79.6%	–	79.6%	1	Whiting, 1997
Total clutch failure from natural causes						
	Not recorded					
Total clutch failure from feral predators						
	Not recorded					
Proportion of clutches killed by nesting turtles						
	Not recorded					

2.2.10 HATCHLING SEX RATIO

Hatching sex ratio has not been measured for any Australian nesting population.

The sex of *L. olivacea* hatchlings, as with other species of marine turtle, is a function of the nest temperature during incubation. Males result from nests incubating below a pivotal temperature and females from above (McCoy *et al.* 1983; Mohanty-Hejmadi and Dimond 1986).

The pivotal temperature has not been measured for the Australian *L. olivacea* population. However, pivotal temperature is ~30 ^{o}C for the *L. olivacea* stock nesting at Nancite, Costa Rica in the east Pacific Ocean (McCoy *et al.* 1983) and ~29 ^{o}C for the Orissa, India in the northern Indian Ocean (Mohanty-Hejmadi and Dimond 1986). Extrapolation of these values to determine the sex ratios of hatchlings in an Australian population should be used cautiously.

2.2.11 AGE and GROWTH

Absolute age has not been measured with wild *L. olivacea*. No growth measurements have been recorded for *L. olivacea* in Australia.

2.2.12 POST-HATCHLINGS

There are no data on the distribution and diet of post-hatchling *L. olivacea* in the Australian region (Limpus *et al*, 1994). Post-hatchlings are expected to drift within off shore continental shelf and oceanic surface waters feeding on plankton (Bolten, 2003).

The duration of this life history phase has not been recorded.

2.2.13 ADULT and IMMATURE TURTLES

In the eastern Pacific Ocean, *L. olivacea* utilises oceanic pelagic waters during the entire post-hatchling, immature and adult life history phases (Plotkin, 2003; Bolten, 2003). However, the Australian *L. olivacea* population behaves differently with at least a substantial part of the immature and adult population foraging over shallow benthic habitats from northern Western Australia to southeast Queensland (Harris, 1994). Satellite telemetry studies of post-breeding migrations of adult females have confirmed this with all five turtles remaining within continental shelf waters (Whiting, 2004). Until there are data to the contrary, it can be accepted that adult, Australian *L. olivacea* forage on benthic communities on the northern Australian continental shelf.

Feeding habitat:
Lepidochelys olivacea is wide spread and regularly encountered by fishers over soft bottom habitats along the east Australian coast inside the Great Barrier Reef from south Queensland northward to Torres Strait, and through Torres Strait, Gulf of Papua, Gulf of Carpentaria, Arafura Sea to at least offshore of Exmouth Gulf in Western Australia (Harris, 1994; Limpus, 1975; Poiner and Harris, 1996; Robins and Mayer, 1998; Robins *et al.* 2002). For five adult females tracked via satellite telemetry from Cape van Dieman, the foraging areas lay 427–1358 km distant from the nesting beach (Whiting, 2004).

Isolated individuals have been beach-washed in New Zealand, Victoria and Tasmania and trawled in South Australia (Limpus and Roper, 1977; EPA Marine Turtle Conservation database). These are regarded as waifs from the normal tropical distribution of this species.

Except for a single capture in Edgecombe Bay in central Queensland (I. Bell, pers. Comm.), the species has not been recorded living in coral reef habitat or shallow inshore seagrass flats. The species was most frequently captured at 6–35 m depth within the Queensland east coast trawl fishery (Robins and Mayer, 1998).

A substantial part of the coastal foraging habitat of *L. olivacea* in eastern Australia is contained within Queensland and Australian Government marine parks (The Great Barrier Reef World Heritage Area since 1981 [Lucas *et al.* 1997] and the associated Great Barrier Reef Marine Park since 1975 and adjacent Queensland State Marine Parks since 1973) that encompasses almost the entire coastal waters off eastern Queensland and spanning approximately 14^{o} of latitude north from Baffle Creek to Cape York.

Diet
Within the neritic habitats of northern Australia, adult and large immature *L. olivacea* are carnivorous, feeding principally on gastropod molluscs and small crabs (Conway, 1994; unpublished data, EPA Queensland Turtle Conservation Project).

Population structure and dynamics
The population structure in feeding areas is poorly described for all parts of its life history in Australian waters. Size classes of immature to reproductively mature adult turtles captured in prawn trawls in the Arafura Sea and Gulf of Carpentaria have ranged from 50 to ~90 cm curved carapace length (Harris, 1994; Robins *et al.* 2002) and 20 to 80 cm in eastern Queensland (Robins and Meyer, 1998).

Duration of the neritic life history phase has not been described. Sex ratio has not been measured for any component of the populations in Australian foraging areas.

Large crocodiles, *Crocodylus porosus*, are predators of adult female *L. olivacea* on the nesting beaches (Chatto, 2004). This predation was probably depressed during past decades of hunting-depleted *C. porosus* populations across Arnhem Land (Webb and Manolis, 1998). Crocodile predation of nesting *L. olivacea* females should be increasing with the recovery of the crocodile population in response to their management.

Survivorship
Annual survivorship has not been quantified for any component of the Australian immature or adult populations.

3. ANTHROPOGENIC MORTALITY and DISEASES

Based on available data, it is not possible to quantify the present magnitude of cumulative mortality from the wide array anthropogenic sources impacting *L. olivacea* within Australia (Figure 5). Additional mortality from various sources including longline and gill net fisheries can also be expected to impact on for these turtle populations as they migrate within oceanic waters and adjacent waters in neighbouring countries.

5a. Adult male *L. olivacea* among trawl bycatch, Northern Prawn Fishery, before Turtle Excluder Devices (TEDs). *Photograph from Bureau of Rural Sciences NPF trawl bycatch monitoring project.*

5b. Four large immature to adult-sized *L. olivacea* dead in a drift net beach-washed north of Duyfken Point, Weipa Queensland. *Photograph by Vance Wallin.*

5c. Adult female *L. olivacea* (K34155) killed by boat strike and beach-washed at Moore Park, eastern Queensland, January 2000.

5d. Dingos preying on *L. olivacea* eggs, Imula Beach, Melville Island, Northern Territory.

Figure 5. **Illustrations of a range of anthropogenic impacts on *L. olivacea*** in northern Australia. *Records from EPA Qld Marine Wildlife Stranding and Mortality database.*

There has been no commercial harvest of *L. olivacea* within Australia since European settlement in 1788. Currently, commercial harvest is not being permitted under any State or Federal legislation in Australia.

3.1 INDIGENOUS HARVEST FOR FOOD

Indigenous peoples with a recognised Native Title right can legitimately hunt marine turtles in Australia for traditional, non-commercial purposes within their respective traditional country.

Indigenous coastal people from Arnhem Land collect eggs and nesting turtles along mainland and island beaches during the dry season. Being one of the main nesting turtle species in this region, *L. olivacea* is part of the traditional harvest (Guinea, 1990; Kennett *et al.* 1998). Similarly, *L. olivacea* eggs are collected by indigenous communities along the beaches in western Cape York Peninsula, Queensland.

Egg and/or hatchling and adult turtle harvest for human consumption has not been quantified for the majority of coastal indigenous communities. However, 16% of clutches collected for local consumption during the Nanydjaka beach survey in NE Arnhem Land in 1995 were *L. olivacea* (Kennett *et al.* 1998). Limpus and Chatto (2004) indicated that dog and varanid predation of *L. olivacea* eggs on Melville Island (Figure 5d) needs to be controlled if sustainable harvest for human consumption of eggs was to occur.

3.2 ACCIDENTAL CAPTURE IN FISHING GEAR

3.2.1 SHARK CONTROL PROGRAM

For several decades*, Lepidochelys olivacea* have been infrequently captured in Queensland Shark control Program (QSCP) gear (Limpus, 1975). Tagging of turtles captured in the QSCP commenced in 1993. During the following 11 years, only two *L. olivacea* were identified among the captured turtles and both were released alive (unpublished data, EPA Queensland Turtle Conservation Project). Mortality of *L. olivacea* from the existing QSCP can be considered to approach zero.

3.2.2 COMMERCIAL FISHERIES

There has been no long-term, systematic collection of statistics on the incidental mortality of *L. olivacea* in fishing gear in northern Australia. Isolated data sets suggest that the total mortality has, and continues to be substantial.

Shark gill nets

Approximately 250 *L. olivacea* were estimated to have drowned in one shark net in a 2 week period approximately 4 km off-shore in Fog Bay, Northern Territory from 15–30 November 1991: 2000 m of bottom set monofilament net (mesh size = 42.5 cm, drop = 12 m) (Guinea and Chatto, 1992). These dead turtles included large immature and adult sized *L. olivacea*. This type of fishery was banned in the Northern Territory following this event. This particular fishing gear had been in use for less than a year when this event occurred (D. White, pers. comm.). There are still no bycatch data from the N3 gill net fishery (high tide to three miles seaward). The volunteer observer program on 20% of the fishers in the N9 (3–9 miles seaward) in the eastern Gulf of Carpentaria) gill net fishery has recorded no *L. olivacea* bycatch.

Trawling

The interaction between *L. olivacea* and trawl fisheries (Figure 5a) in northern Australia has only been documented in recent decades. The following summarises the more significant available data pertaining to the *L. olivacea* captures in trawl fisheries in Australian waters:

- The earliest record of *L. olivacea* from the Northern Trawl Fishery dates from the mid 1970s when a specimen was collected for the University of New England Zoology Department teaching collection.
- *Lepidochelys olivacea* was the most commonly captured turtle in prawn trawls of northern Australia recorded by trained onboard observers prior to 1990 (EPA Queensland Turtle Conservation Project, unpublished data): 34% of 90 turtles in the Gulf of Carpentaria; 2% of

45 turtles between Cape York and Princess Charlotte Bay; 60% of 30 turtles in the Townsville area.

- Melville Bay, northeast Arnhem Land, May 1986: A trawler skipper who was a volunteer within the Queensland Turtle Conservation Project reported capturing and drowning *L. olivacea* in each shot of his prawn trawl. He also reported approximately 20 trawlers operating in the vicinity and each was expected to be catching 1–2 *L. olivacea* per night with almost all coming up dead. This suggests that there could have been a nightly kill of tens of *L. olivacea* for the trawling fleet working in this area at that time.
- During a two year CSIRO study of turtle bycatch in the northern prawn fishery, *L. olivacea* accounted for 15%–10% of the 165 and 161 turtles trawled in 1989 and 1990 respectively. The *L. olivacea* impacted by this fishery encompassed the adult and large immature size ranges. Catch rate = 0.0071 ± 0.0015 turtles per trawl in 1989 and 0.0052 ± 0.0014 with a 8.3% probability of being landed dead in the sorting tray in 1989 and 18.8% probability in 1990. Compared to the other species, *L. olivacea* had a very low probability of being drowned when captured in the trawls. This study estimated that the northern prawn fishery killed approximately 84 and 80 *L. olivacea* in 1989 and 1990 respectively (Poiner and Harris, 1994,1996).
- In a few weeks prior to September 1995, 12 dead adult and large immature sized *L. olivacea* (CCL = 51–67 cm) were beach-washed in Fog Bay, western Northern Territory (Guinea *et al.* 1997). Their deaths were attributed to trawl bycatch mortality.
- Based on a logbook recording program, turtle bycatch in the Queensland East Coast Trawl Fisheries (ECTF) and in the Torres Strait Prawn Fishery (TSPF) during 1991–1996 was investigated (Robins and Mayer, 1998). This study found that *L. olivacea* was an uncommonly reported turtle in the ECTF bycatch (6% of 1,527 turtles reported; range per year = 4% – 10%). *L. olivacea* was less common among the reported turtles in the TSPF bycatch (<1% of the 151 turtles reported.). The *L. olivacea* impacted by these fisheries encompassed the adult and large immature size ranges. The extrapolated mean annual catch of *L. olivacea* within the entire fishery was estimated at 323 in ECTF and 18 in TSPF. The total annual direct mortality associated with these captures (assuming that some non-resuscitated comatose turtles could die on release) could be in the range of 3%–10% (n = 9–32) in ECTF and was not determined in TSPF. The majority of *L. olivacea* were trawled along the coast from Mackay north to Cape York.
- Based on reports from trained crew, turtle bycatch in the Northern Prawn Fisheries (NPF) during 1998–2001 was investigated (Robins *et al.* 2002). This study spanned two years before the compulsory introduction of Turtle Exclusion Devices (TEDs) into the NPF in 2001 and two years after their introduction. About 30% of the turtles reported captured were *L. olivacea* with the majority of captures occurring in western and southern Gulf of Carpentaria. The introduction of TEDs to the fishery resulted in a two order of magnitude reduction in turtle captures in the NPF trawls.

To date, no study has extrapolated the historical data to quantify the impact on marine turtles by the northern prawn fishery and east coast trawling fleets during the 1970's. During this time the number of vessels escalated and the industry began using larger boats, towing bigger nets for longer shot (immersion) times than in the late 1960s when monitoring of the turtle nesting populations in south Queensland commenced (M. Helmuth, pers. comm. January 1982). Trawl fisheries of Queensland, Northern Territory and Western Australia have had the potential to kill hundreds or perhaps thousands of adult and large immature *L. olivacea* annually since the late 1970s. This situation changed as we entered the 21st Century. The compulsory use of TEDs has been regulated in the NPF since April 2000, ECTF since December 2000, TSPF since March 2002, and Western Australian prawn and scallop trawl fisheries since 2002. The process for regulating the compulsory use of TEDs in trawl fisheries was partly facilitated by Otter Trawling being listed under the EPBC Act as a key threatening process (KTP) in 2001 due to the level of bycatch of marine turtles.

An undetermined number of *L. olivacea* are captured in trawl and other fisheries in Indonesian waters of the Arafura Sea (Sahertian and Noija, 1994). There is a high probability that many of these turtles are taken for food or sale by the crews rather than released. These *L. olivacea* are expected to be part of the Australian breeding stock.

3.3 BOAT STRIKE AND ENTANGLEMENT IN FISHING LINE

During eight years of systematic recording of stranding of sick, injured and dead marine wildlife along the Queensland coast during 1996–2003, there have been five *L. olivacea* deaths resulting from collision with a boat or propeller: 3 off Townsville, 1 off Bundaberg (Figure 5c), 1 off Crab Island (EPA Marine Wildlife Stranding and Mortality Database).

3.4 MARINE DEBRIS

During eight years of systematic recording of stranding of sick, injured and dead marine wildlife along the eastern Queensland coast during 1996–2003, there has been one record of *L. olivacea* beach-washed dead as a result of entanglement in fishing line in Hervey Bay.

There have been no records of mortality of *L. olivacea* in eastern Australia resulting from ingestion of plastic or other items of anthropogenic origin during the same period.

3.4.1 GHOST NET ENTRAPMENT

Large amounts of fishing net are discarded or lost from the fisheries of the Gulf of Carpentaria and Arafura Sea and drifts ashore on Queensland and Northern Territory beaches of the Gulf of Carpentaria (Limpus and Miller, 2002; White, 2003). While at sea these nets entangle and kill several species of marine turtle including *L. olivacea*.

The length of time this mortality has been occurring is not clear. An area to the north of the Tiwi Islands in the Arafura Sea and beaches north of Weipa on the Western Cape York Peninsula have been identified where turtles entangled in drifting ghost nets are regularly encountered (White, 2004). Not all ghost nets drift at the surface. Some may drift across an unobstructed bottom (White, 2004). However, both surface, mid water, and bottom drifting net can be snagged on reefs and remain stationary while continuing to catch and kill turtles. This appears to be common on the reefs offshore from the Mapoon-Weipa coast of western Cape York Peninsula (V. Wallin and Lawry Booth, pers. comm.).

In addition, when cyclones pass from the Coral Sea across Cape York Peninsula into the Gulf of Carpentaria each summer, they cause erosion of the western beaches of Cape York Peninsula and the southern Gulf coast. Due to this erosion, possibly tens of thousands of nets can be returned to the sea, continue ghost fishing and re-strand during the weeks to months later. For example, in the six weeks following Cyclone *Abigail* in February 2001, it is estimated that over 4000 nets washed ashore containing in excess of 400 turtles along the eastern Gulf of Carpentaria Coast (Limpus and Miller, 2002). Similar stranding of nets and entangled turtles has been recorded following cyclones in the three years since 2001 (V. Wallen, pers. comm.; EPA Marine Wildlife Stranding and Mortality Database). There are thus two separate issues with regard to the entrapment of turtles in these “ghost nets”: new nets drifting to arriving at the beaches or entangle on reefs each year and recycling of nets from the beaches back to the sea and their subsequent re-stranding.

Turtle entanglement in beach-washed ghost net was been monitored in the vicinity of Cape Arnhem and Port Bradshore during 1996–2003 (Leitch, 1997, 2001; Roeger, 2004). Turtles entangled in ghost nets appear to strand here mainly in the early dry season, April-August (Roeger, 2004).

Turtle mortality in the Gulf of Carpentaria s "ghost net" fishery is unquantified but appears to be hundreds, if not thousands of turtles annually. An unquantified but obvious proportion of the *L. olivacea* mortality in ghost nets are adult and large immature turtles (Figure 5b) (EPA Marine Wildlife Stranding and Mortality Database; Leitch, 1997, 2001; Roeger, 2003; White, 2004).

Mortality data for Northeastern Arnhem Land, detailed 25 (12.9%) large immature and adult sized *L. olivacea* among a sample of 194 marine turtles recorded entangled in beach-washed discarded or lost fishing net which drifted ashore during 1996–2003 with 68% of *L. olivacea* released alive (Roeger, 2004). The extent to which this type of mortality extends further across northern Arnhem Land (Chatto *et al.*1995; White, 2004,2005) or in offshore oceanic waters (Whiting, 2004) is undetermined. In the absence of a rigorous census of these stranded turtles across northern Australia, it is presumed that hundreds of adult and large immature *L. olivacea* are killed annually in these “ghost nets”.

3.5 DISEASE

There are no reports of diseases causing deaths of *L. olivacea* in Australia.

4. POPULATION STATUS

Historically within Australia, research and monitoring of *L. olivacea* has been neglected, primarily because of their "remote" feeding and nesting distribution. It is presumed that the Australian population is small relative to some other countries. Recent genetic analysis has however raised their profile by identifying the Australian stock as unique.

Based on the above review, the principal sources of mortality from non-natural processes impacting the Australian *L. olivacea* population include: bycatch in gill net and otter-board trawl fisheries (hundreds of adult and large immature individuals killed per year over many years), ghost net entanglement (hundreds of adult and large immature individuals killed per year over presumably many years) and significant egg loss through pig and dog predation at a number of rookeries. In addition, at a number of rookeries in the Northern Territory and western Cape York Peninsula, an unquantified proportion of eggs are taken as part of the Indigenous harvest.

Assuming that the population dynamics of *L. olivacea* is not very different to that of the better studied species, such as *Caretta caretta* (Chaloupka, 2003) and *Chelonia mydas* (Chaloupka, 2002), and given the estimate of only a few thousand nesting *L. olivacea* females annually, then the Australian population is unlikely to be able to sustain an annual mortality of many hundreds of large immature and adult turtles and large numbers of clutches over the long term.

There is a distinct possibility that the Australian *L. olivacea* population is already in decline and is one of the most threatened species of marine turtle in Australia. With no monitoring of the population in place, it is impossible to determine its current status with certainty. However, if the precautionary principal is applied, the Australian *L. olivacea* population warrants consideration as an endangered species.

5. CONSERVATION STATUS WITHIN AUSTRALIA

Conservation management of *L. olivacea* within Australia had its beginnings in 1968 with the 18 July 1968 Order in Council under the Queensland Fisheries Act that declared an all year round closed season for the harvest of all species of marine turtles and their eggs for all of Queensland.

L. olivacea currently is recognised as a threatened species in Queensland, Western Australia and Australia generally (Table 5). It warrants consideration for listing as an endangered species across all jurisdictions.

Table 5. Summary of the legally defined conservation status of *Lepidochelys olivacea* for Australia.

	Status	**Legal basis**
International obligations		
Convention for the Conservation of Migratory Species of Wild Animals (CMS)	Appendix I & II	Australia is a signatory state.
Convention for International Trade in Endangered Species (CITES)	Appendix 1	Australia is a signatory state.
Legislation		
Australia including Australian Territories	Endangered Migratory species Marine species	*Commonwealth Environment Protection and Biodiversity Conservation* (EPBC) *Act 1999*
Tasmania	Not listed	*Threatened Species Protection Act 1995*
Victoria	Not listed	*Advisory list of Threatened Vertebrate Fauna in Victoria 2003*
New South Wales	Not listed	*Threatened Species Conservation Act 1995*
Queensland	Endangered	*Nature Conservation Act 1992*
Northern Territory	Data deficient	*Territory Parks and Wildlife Conservation Act 2000*
Western Australia	Rare or likely to become extinct	*Wildlife Conservation Act 1950*
South Australia	Not listed	*National Parks and Wildlife Act 1972*

The Australian Government has jurisdiction over waters three nautical miles offshore to the end of Exclusive Economic Zone (EEZ). In these waters marine turtles are protected under the EPBC Act. The respective Australian States and Territories have jurisdiction over intertidal waters and coastal waters out to three nautical miles offshore from their State lands. The respective State and Territory legislations are applicable to the management of marine turtles in these State and Territories waters. Under the EPBC Act actions in all Australian waters that have, will have or are likely to have a significant impact on marine turtles are subject to a rigorous referral, assessment, and approval process.

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