

Memoirs of the Queensland Museum | **Nature**

56 (1)

© Queensland Museum

PO Box 3300, South Brisbane 4101, Australia
Phone 06 7 3840 7555
Fax 06 7 3846 1226
Email qmlib@qm.qld.gov.au
Website www.qm.qld.gov.au

National Library of Australia card number
ISSN 0079-8835

NOTE

Papers published in this volume and in all previous volumes of the *Memoirs of the Queensland Museum* may be reproduced for scientific research, individual study or other educational purposes. Properly acknowledged quotations may be made but queries regarding the republication of any papers should be addressed to the Director. Copies of the journal can be purchased from the Queensland Museum Shop.

A Guide to Authors is displayed at the Queensland Museum web site www.qm.qld.gov.au

A Queensland Government Project
Typeset at the Queensland Museum

A summary of Marine Turtle records for Norfolk Island

Kellie PENDOLEY

Pendoley Environmental Pty Ltd, Locked Bag 13, Canning Bridge WA 6153, Australia. Email: kellie.pendoley@penv.com.au

Margaret CHRISTIAN

Consultant Ecologist, PO Box 999, Norfolk Island 2899, Australia. Email: justmarg@hotmail.com

Citation: Pendoley, K. & Christian, M. 2012 02 17: A summary of Marine Turtle records for Norfolk Island. *Memoirs of the Queensland Museum – Nature* 56(1): 67-78. Brisbane. ISSN 0079-8835. Accepted: 13 May 2011.

ABSTRACT

Nothing has been published in the modern literature on the status of marine turtles at Norfolk Island although their presence has been recognised since 1793 (Fidlon & Ryan 1980). This study brings together all the available published, anecdotal and field survey data on marine turtles at Norfolk Island so that the status of habitat usage could be established. The results confirm the Norfolk Island group is used for foraging by resident adult and juvenile *Chelonia mydas* (Green) turtles and adult *Eretmochelys imbricata* (Hawksbill) turtles. The natal beaches for these resident animals are thought to be Melanesian and Polynesian islands to the north and the beaches of north eastern Australia. While juvenile hawksbill turtles have not been recorded foraging at Norfolk Island they are the most common species and age class recorded in the island's strandings data. The confirmation of marine turtles at Norfolk means that any future development proposals must include assessment of project impacts on these listed threatened species under Australian Federal legislation and their marine bioregional processes. □ *green, hawksbill, loggerhead, nesting, foraging, stranding, turtle.*

Norfolk Island and its two smaller satellite islands, Nepean and Phillip lie on the Norfolk Ridge which joins New Zealand to New Caledonia (Figure 1). It is 1126 kilometres north west of Auckland (New Zealand) and 1450 kilometres east of Brisbane (Australia). The island group (referred to jointly as Norfolk unless otherwise stated) is located atop a 100 km long plateau and the larger two are the remnants of recent volcanic activity (Jones & McDougall 1973). Nepean is younger, composed entirely of calcarenite and formed when coral reefs were exposed during the last Ice Age. The coastlines of all three are characterised by tall sheer cliffs that drop straight into the ocean and sandy beach development is absent, poorly developed or restricted amongst the group (Fig. 2). Norfolk

Island, the largest and most accessible was selected for the first (European) settlement in 1788 and it is from this period that the first reports of marine turtles were made by Philip Gidley King. Nothing has been published on the status of marine turtles at Norfolk Island since that time.

OCEANOGRAPHY AND CLIMATE

The fine scale oceanography of the Norfolk area is complex and poorly understood. Regionally, the anticlockwise South Equatorial Current (SEC) carries tropical water from the Coral Sea west towards Australia (Fig. 3) before turning into the East Australian Current (EAC). The current generates large ocean eddies up to 200 km across

TABLE 1. Historical record extracts pertaining to marine turtle observations from Norfolk Island, 1788 – 1790, (Hunter 1793, except where noted) *Modern name is Emily Bay.

Observation date	Observation place	Historical record extract
4/3/1788	Anson Bay	Supply Quarter Master drowned attempting to capture a turtle (Clark 1791)
9/3/1788	Turtle Bay*	'Turned 2 on beach, weighed 200 weight each' (this equals about 224 lbs or 89kg), recorded 'a great number of turtle swimming about'
14/3/1788	Turtle Bay	'I turned 3 more turtle brought to settlement. Generally saw 3 lying on the beach at low water, in clear weather but when cloudy they never land.' (Fidlon and Ryan, 1980)
5/4/1788	Turtle Bay	'Several turtle has been seen in the bay but none came onshore.'
6/4/1788	Turtle Bay	'4 turtle seen in bay but none came onshore'
9/4/1788	Turtle Bay	'1 turtle onshore but did not disturb it.'
8/5/1788	Turtle Bay	'Not seen turtles for some time, the cold weather has probably driven then to a warmer climate.'
2/9/1788	Turtle Bay	'A turtle seen on the beach but soon went off without being disturbed.'
3/9/1788	Turtle Bay	'A turtle staid 2 or 3 hours on the beach today'
4/9/1788	Turtle Bay	'A turtle turned today had his (sic) back pierced thro as if done by a peg.'
15/9/1788	Turtle Bay	'3 turtle on beach'
16/9/1788	Turtle Bay	'1 turtle on beach'
16/10/1788	Turtle Bay	'I turned a turtle which weighed 200 lbs'
30/10/1788	Turtle Bay	'Turned a turtle of ~ 160lb'
13/11/1789	Cresswell Bay	'Turtle turned in Cresswell Bay'
24/3/1790		King left Norfolk Island on this date
14/7/1791	Duncombe Bay	'2 marine went to Duncombe Bay fishing and returned with a turtle ~ 200 weight' (Clark 1791)

that rotate anticlockwise as they move eastward. An arm of this eastward flow, the Tasman Front, carries EAC waters past Lord Howe and into the Norfolk Island province (DEWHA 2007b). (It is strongest in summer (peaking in February), reaching speeds of 5 knots, and is weakest in winter. It is confined to the top 500 m of the water column and is 100 km wide. The position and strength of the current is highly variable from season-to-season and year-to-year (Nilson & Cresswell 1981; Ridgeway & Dunn 2003; Williams *et al.* 2006b; Ridgeway & Hill 2009). As a consequence warm currents may approach the island from the north or east for half a year and from the west or south the rest of the year while in other years the flow is from the west or south all year (Cresswell 1989).

The surrounding sea strongly influences temperatures at Norfolk Island. Annual air temperatures range from 18°C to 23°C (BOM 2011). Sea water temperatures vary with the location and direction of the regional currents, ranging from 18°C to 26°C (Darren Bates pers. comm.)

BIOLOGY

The composition of marine flora and fauna at Norfolk is representative of the species found along the eastern coast of Australia and in the tropical seas to the north and east reflecting the sources of the major regional currents that flow past the island group. Marine flora and fauna of Norfolk have been poorly studied and no systematic mapping of habitats has been

Marine Turtle records on Norfolk Island



FIG. 1. Melanesian, Micronesian and Polynesian Island groups located north of Norfolk Island.

conducted. The published studies to date suggest the island supports a diverse mix of tropical and temperate species; a rich marine benthic algae assemblage comprising 236 species (Millar 1999); abundant and locally luxuriant assemblages of hermatypic corals (39 species) both inside the Kingston lagoon and elsewhere around the island group (Brook 1990), 254 coastal tropical and subtropical fish species (Francis 1993) and 60 tropical and temperate echinoderms (Hoggett & Rowe 1988; O'Hara 2008). Local fisherman also report patches of seagrass are present off the north west coast of Norfolk.

Bioregional Planning by the Commonwealth Government includes the Norfolk Island Province in their East Marine Region (EMR) and noted the island was one of a limited number of temperate isolated oceanic islands worldwide, supported some of the most southerly coral reefs in the world and was unique within the EMR in that the demersal assemblages were more closely related to New Caledonia than with eastern Australia. The planning process compiled all available information to describe ecosystems

and ecosystem function for the region. Marine turtles were not identified for the Norfolk Island Province during this process (Brewer *et al.* 2007, DEWHA 2007a; DEWHA 2007b).

Recent marine development proposals for Norfolk Island have triggered the *Environmental Protection and Biodiversity Conservation Act 1999*, which protects among other values, threatened and migratory species such as marine turtles. This study seeks to formally recognise the presence of marine turtles at Norfolk Island and provides a preliminary review of the species present and their distribution around the Norfolk Island region.

METHODS

The information sources consulted during the preparation of this review included: the historical and modern literature; the Norfolk Island Parks and Wildlife marine turtle stranding file notes; local resident wildlife biologist field notes (M. Christian); local divers, fishermen, surfers and cliff top residents. Additional data was collected during an ultra-light aerial survey of near shore

Pendoley & Christian

TABLE 2. Current records of reported marine turtle sightings at Norfolk Island, * aerial survey by ultra-light aircraft.

Observation date	Observation place	Size	Species	Reference/observer	Notes
Regularly	Phillip Island	Adult	? Green	Honey McCoy	Long time resident and natural historian, specialising in Phillip Island
Regularly	All around Norfolk	Adult and juveniles	Green	Jack Marges	Long term resident and dive operator. Believes all turtles he has seen around Norfolk are green turtles. See turtles out to 30m deep (limit of his diving range). Frequently see adult and juvenile (dinner plate) sized animals.
Regularly	Ball Bay	Adult and juvenile	? Green	David Biggs	Mooring master for oil and gas tankers in Ball Bay, has noted turtles every time he moors a ship, this occurs ~ once a month year round.
Regularly	Ball Bay	Adult and juvenile	? Green	Tony Cook	Cliff top resident. Generally sees 4-5 turtles in the south side of the Bay around noon. Not seen as regularly since temporary jetty groyne was constructed, and later removed, from Ball Bay (2005/2006)
Regularly	Simons Water	?	? Green	Arthur Evans	Frequently observes turtles from the cliffs at Simons Water.
Regularly	Kingston	Adult	? Green	Steve Ryves	A keen wind surfer
Regularly	Bumboras	Adult	? Green	Steve Ryves	A keen wind surfer
Regularly	The Cord	Adult	Green	Byron Adams,	K Pendoley observed 3 through binoculars on 21 Oct 2004, confirmed species
26/02/2001	Ball Bay	Adult	Green	Karlene Davies,	Diver, species confirmed from photo by K Pendoley
16/01/2006	Nepean Island	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Cemetery Bay	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Bumboras	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
16/01/2006	Kingston jetty	Adult	Green	K Pendoley/R Ryan*	Size and shape suggest green turtle
24/01/2006	Phillip Island	Adult	Green	K Pendoley	Observed through binoculars from top of tall cliff, size and shape indicated green
25/01/2006	Anson Bay	Adult	Green	K Pendoley	Observed through binoculars from top of tall cliff, size and shape indicated green
20/03/2006	Hundred Acres	Adult	Green male	Robert Ryan	This turtle is seen at this location regularly, photographed head
1/07/2007	Duncombe Bay	Adult	Hawksbill	Rob Morely	Diver, the image includes endemic Norfolk Island Big Eye fish
29/09/2008	Phillip Island	?	?	Jarrold Evans	Diver and science teacher
8/10/2008	Duncombe Bay	Adult	Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
8/10/2008	Duncombe Bay	Adult	Green	Jarrold Evans	Diver and science teacher, underwater image
14/01/2009	Duncombe Bay	Adult	Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
26/01/2009	Anson Bay	Adult	? Hawksbill	Jarrold Evans	Diver and science teacher, underwater image
1/02/2009	Nepean Island	Adult	?	Jarrold Evans	Diver and science teacher, underwater image

Marine Turtle records on Norfolk Island

TABLE 2. continued ...

Observation date	Observation place	Size	Species	Reference/observer	Notes
21/07/2009	Cascade Bay	Immature	Green	Kellie Pendoley	turtle comes into jetty with sharks when fish cleaning underway
23/07/2009	Bird / Cathedral Rock area	Adult	Green	Kellie Pendoley	seamen see turtles here regularly
9/01/2010	Anson Point North	Immature	Green	Kellie Pendoley	partial circumnavigation of the island by boat (weather restricted)
9/01/2010	Jacobs Rock	Immature	Green	Kellie Pendoley	partial circumnavigation of the island by boat (weather restricted)
9/04/2010	Kingston Bay	Adult	Green	Jarrold Evans	Diver and science teacher, Swiss Cheese area
9/09/2007	Kingston Bay	Juvenile	?	Arthur Evans Ken Christian	Both described a small (~15cm long) turtle with spines at the joints of the scales along the back, light brown colour.

waters of Norfolk and Nepean Islands (16 January 2006), and two boat based surveys circumnavigating Norfolk Island, Phillip and Nepean Islands (23 July 2009 and 9 January 2010).

RESULTS

Historical records

Prehistory studies of Norfolk Island Polynesian settlements have found scant evidence of marine turtle remains in the Emily Bay sites examined, being restricted to pieces of carapace (Smith *et al.* 2001). Hoare (1999) has suggested early visitors would have found food sources in turtles and turtle eggs, however, there is no supporting evidence from the historical literature to indicate turtles nested (i.e. laid eggs) at Norfolk Island.

The earliest records relating to marine turtle sightings were made by Philip Gidley King (Fidlon & Ryan 1980) during the first attempts to establish a settlement on Norfolk Island (Table 1). King arrived at Norfolk Island on 1 March 1788. His personal journal, which contains detailed records of the amount of fish and turtles collected during his occupation of the island, first reported

turtles at Norfolk Island on 3 March 1788 when a Supply Quarter Master was drowned trying to catch a turtle. Four days later turtles were found basking on the shores of what was named 'Turtle Bay' (the modern name for the bay is Emily Bay).

King immediately recognised the value of the turtles found basking in Turtle Bay and banned anyone from going near the beach and frightening them. Numerous turtles were seen swimming in the bay in March that year and King's journal entry for 14 March 1788 notes that every day at low water they saw "...three or four turtles lying on ye (*sic*) beach asleep in ye (*sic*) sun, but when it is cloudy they never land...", and "...this, together with there being no appearance of any pits where they lay their eggs, leads me to suppose that they do not breed on any part of the island; especially as this is the only place where there is a possibility of them to make their pits." (Fidlon & Ryan 1980).

Between April 9 and 1 September 1788 (austral winter) no records of turtle observations were recorded by King and he comments that this may have been due to the cold weather driving them to a warmer climate. Reference is not made to turtles again until the following spring when turtles were observed between September and November

1788. King remained on Norfolk until 24 March 1790, however, no further mention of turtle was made in his journals.

The final historical record of marine turtles at Norfolk Island was documented by Lt Ralph Clark when two marines fishing at Duncombe Bay captured a turtle. This record was from mid winter, July 1791, suggesting the animal was captured while it was foraging (Fidlon & Ryan 1981).

Sightings

Modern day confirmed sightings of live turtles around Norfolk Island are most commonly of *Chelonia mydas* (green) and *Eretmochelys imbricata* (hawksbill) turtles (Table 2). Green turtle sightings are spread around the entire coast of Norfolk Island and are seen year round. Both adult and juvenile turtles are observed around the island.

The photographic hawksbill records supplied by J. Evans confirm that more than one adult hawksbill is present at Norfolk and that this species is present in both summer and winter (January, July and October).

The description given for the juvenile turtle observed off the Kingston jetty on 9/9/2007 suggests this may have been a very young *Caretta caretta* (loggerhead). The witnesses description of a small (~15 cm long) turtle with spines at the joints of the scales along the back and a alight brown coloration is strongly suggestive of a young loggerhead turtle (Table 2).

Strandings

Table 3 lists the stranding data for Norfolk Island. This data comes from a wide range of sources including the turtle file held by the Norfolk Island National Parks and Wildlife office, The Norfolk Islander newspaper and private individuals holding skeletal, tissue, or photographic material. All sources have been listed in Table 3 and where the species is listed it has been confirmed by Margaret Christian, Dr Bryan Gartrell DVM and/or Dr

Kellie Pendoley. Age class was determined from carapace measurements and or photographs.

Of the 15 strandings records, 7 were green turtles, 6 were hawksbill turtles and 2 were unknown. Only one was a mature animal (NI006), the rest were immature green or hawksbill turtles. The size of the single 'hatchling' record cannot be confirmed due to the loss of the specimen (NI005, Table 3) and it is possible that this specimen was a post-hatchling. Strandings were most frequent in Ball Bay (n=9) followed by Slaughter Bay (n=3).

A juvenile green turtle tagged in a hatchery in Tahiti is the only tagged individual that has been found at Norfolk Island (NI004, Table 3). This turtle was released from Scilly Atoll on 1 October 1993 and found at Norfolk Island, 4480 km south west 17 months later on 4 March 1995. At the time of tagging it measured 44 cm curved carapace length (CCL), at recapture on Norfolk Island it was measured at 60 cm CCL. The tag was supplied by the University of Hawaii, No. P782

DISCUSSION

The basking behaviour of the green turtles described by King has also been documented in the historical literature from New Caledonia, Hawaii and the Galapagos Islands, however, the available literature suggests that Hawaii and Shoalwater Bay in Queensland are the only locations where this behaviour is still observed (Balazs 1980; Balazs & Ellis 2000; Pritchard 1982). Basking green turtles in Hawaii include both male and female animals, year round with a seasonal peak in summer (Balazs 1980; Whittow & Balazs 1982; Balazs & Ellis 2000). The basking turtles in Shoalwater Bay in New South Wales, Australia, are all green turtles that range in size from small immature to adult sized animals and are typically found basking on seagrass beds and intertidal platforms after the tide recedes. The year round presence of these animals suggests they are resident foraging animals (Limpus *et al.* 2005).

Marine Turtle records on Norfolk Island

TABLE 3. Records of marine turtle stranding at Norfolk Island since 1990.

Specimen code	Specimen collection date	Place	Condition	Age class & Species	Measurements (cm)	Notes
NI001	22/11/90	Slaughter Bay	alive	immature Green	55 SCL -	Tangled in net. Animal in good condition, flesh wounds from net.
NI002	16/11/92	Slaughter Bay, inside reef	Alive,	?	43 SCL 42.5 SCW	Exhausted and bleeding from cloaca, deep scoring on carapace
NI003	22/9/93	Ball Bay	Dead	Immature Green	50 SCL -	
NI004	4/3/95	The Cord, Duncombe Bay	Alive	Immature Green	60 SCL -	Tagged turtle. Collected as a hatchling from Scilly Atoll north of Bora Bora and head started in Tahiti. Tagged 1 Oct 1993, U of Hawaii tag, number P782.
NI005	Mid 1990s	Ball Bay	Dead	Hatchling/ Post-hatchling species unknown	- -	Dead and desiccated, washed ashore inside a plastic ice cream container. Specimen eaten by pet dog.
NI006	~1995	Anson Bay	Freshly dead	Mature green	140 SCL over flattened carapace	Turtle was dug up from a terrestrial location, measurements made of the flattened carapace. Species confirmed from skull. Animal found well above the high tide line following a severe storm.
NI007	12/8/03	Ball Bay	Freshly dead	Immature green	78 CCL 73.5 CCW	No visible damage
NI008	March 2005	Ball Bay		Immature Hawksbill	36.25 CCL 33.75 CCW	Smaller of the two specimens held on Norfolk
NI009	19/4/05	Ball Bay	Decomposing (wet)	Immature hawksbill	- -	Old damage noted on edge of carapace. Buried. Skeletal material held on Norfolk Is.
NI010	June 2005	Ball Bay	Freshly dead	Immature hawksbill	- -	
NI011	November 2005	Ball Bay	Freshly dead	Immature hawksbill	- -	Turtle seen swimming in waves at Ball Bay a few days earlier. Check by Dr Bryan Gartrell DVM indicated the animal was dehydrated and lacked vigour. It was covered in algae. No obvious signs of injury, no entanglements.
NI012	November 2009	Ball Bay	Alive	Immature hawksbill	- -	Found alive, removed 4 small blue crabs from skin folds between carapace and rear flippers, released at Kingston.
NI013	24/8/2009	Point Hunter	Dead and rotting	Adult green	44CCL 45CCW	Washed ashore on rocks, crushed skull
NI014	19/10/2008	Slaughter Bay	Alive	Immature green	- -	Vet treated with antibiotic and vitamin shots, animal gone from beach next day
NI015	19/6/2010	Ball Bay	Dead	Immature hawksbill	- -	Half of head missing

While basking behaviour at Norfolk Island was only observed during the warmer summer months, it was not related to nesting activity. King was familiar with the ecological requirements for turtle nesting (i.e. warm temperatures and

adequate sand depth) stating in his journal “We generally saw three [adults] lying on the beach on low water in clear weather, but when cloudy, they never land; this, together with there being no appearance of any pits where they lay their eggs,

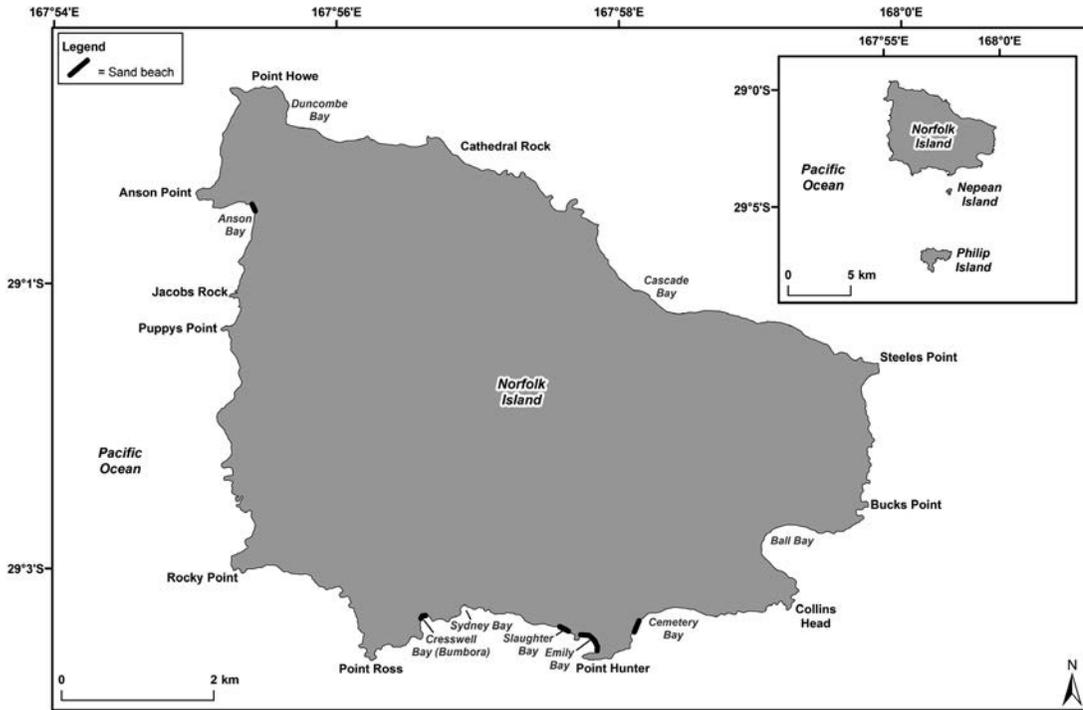


FIG. 2. Map of Norfolk Island showing sand beaches, coastal features and names

leads me to suppose that they do not breed on any part of the island, especially as this is the only place where there is a possibility for them to make their pits" (Fidlon & Ryan 1980). The basking turtles documented by King were therefore likely to be from a non breeding resident population, similar to those documented by Balazs (1980) from the French Frigate Shoals in Hawaii.

The historical records further suggest that the basking population was small, with only a few turtles ever observed at one time. This is consistent with the results from prehistoric archaeological surveys at Norfolk Island which found a low abundance of turtle bones from a prehistoric Polynesian settlement on the island (Smith *et al.* 2001). King does not refer to turtles after the first year of occupation and it is possible the basking

turtles that were not killed were driven away by the presence of the humans.

Potential nesting habitat within the group of islands is limited to 6 small (50 m – 350 m long) beaches on Norfolk Island. The most stable deep sand beaches occurring on the cooler, south (Slaughter and Emily Bay) and east (Cemetery Bay), coasts of the island while the sand at Anson Bay and along the Bumboras coast is very shallow (<0.5 m deep) and dynamic.

Preliminary sand temperature studies carried out during February and March 2006 found sand temperatures were not significantly different (ttest $p < 0.05$) between beaches, mean $25.12^{\circ}\text{C} \pm 0.98^{\circ}\text{C}$ (range 21.5°C to 26.5°C). While recognising the limitations on the amount of data, the sand temperatures at Norfolk fall at and below the 26°C – 33°C range required for successful

Marine Turtle records on Norfolk Island

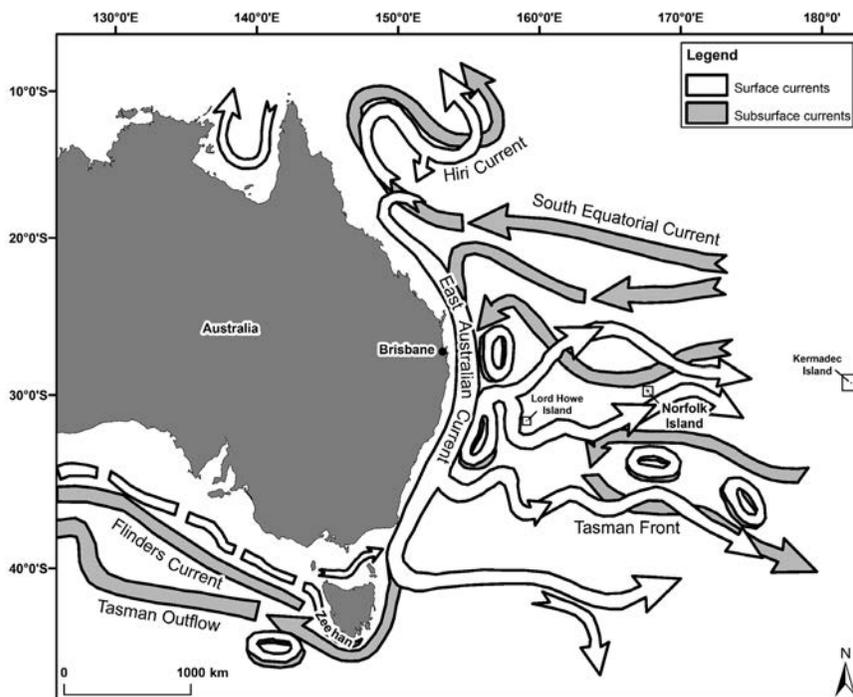


FIG. 3. Schematic of the main ocean currents off eastern Australia (source: Ridgeway & Hill. 2009)

egg incubation (Miller *et al.* 2003; Miller 1982; Milller 1985; Miller & Limpus 1981). Taken together with the lack of any historical or modern day evidence (document or anecdotal) of eggs, nesting attempts or live hatchling recorded at Norfolk it is reasonable to conclude Norfolk is not an active rookery.

The regular observations of live healthy juvenile and adult green turtles and adult hawksbill turtles in Norfolk coastal waters strongly suggests that these species and age classes are resident at the island. The presence of algae (Millar 1999) and coral patch reefs (Francis 1993) provide the necessary (algae) foraging habitat for the resident green turtles (Limpus 1978, Garnett & Murray 1980) and reef species (algae, ascidians, sponges, bryozoans and molluscs) for the hawksbill turtles (Limpus 1978, 1979). To date there have been no confirmed

in-water records of juvenile hawksbill turtles; every record has been of dead, dying or weak animals stranded in Ball Bay. The presence of resident adult hawksbill turtles at Norfolk implies that sub-adults should also be present in the resident population and are likely to be confirmed as the marine fauna of Norfolk are more fully studied.

Regionally Norfolk Island, together with Lord Howe Island, probably represents the southern boundary of foraging range for green and hawksbill turtles. While no published information is available for Lord Howe, Hunter (1793) reported abundant turtles (probably green turtles) at the island; modern tour operators report green and Hawks Bill (sic) turtles at the island (Marine Adventures, Lord Howe Island, 2011). Both species have been recorded from New Zealand as strandings, carried south on seasonally variable flows from the EAC (McCann 1966; Gill 1997).

Hirth (1993) and Pritchard (1982) note that green turtles are seen in the ocean around New Zealand and the Kermadec Islands, however, their resident status (i.e. foraging or single individuals carried there on seasonal currents) was not reported.

Nesting and foraging habitats for both green and hawksbill turtles occur off north Eastern Australia and throughout the islands and waters of the Coral Sea regions encompassing Micronesia, Melanesia and Polynesia (Figure 2) situated in a wide band of ocean to the north of Norfolk Island (Limpus 2008; Trevor 2010). Compiled data on tagged turtle nesting foraging and migration in the regions show that breeding and juvenile green and hawksbill turtles display a general westward movement through the area (Trevor 2010), which is consistent with the direction of the South Equatorial Current (SEC). Depending on the strength and location of the SEC and the EAC and its associated arms, eddies and convergent zones it is reasonable to expect turtles would be carried out of the Coral Sea area to Norfolk Island. The size of the resident foraging population is likely a function of both the probability of animals actually reaching the island and the carrying capacity of the food resources.

The regularity with which juvenile hawksbill turtles strand in Ball Bay is noteworthy. The cause for these strandings is not known and in the absence of systematic marine turtle population data, reliable habitat mapping and local oceanographic modelling it is not possible to determine if these animals are from the resident foraging population or if they have been brought into the island by the spatially and temporally variable oceanic currents.

Both green and hawksbill turtles are protected under the EPBC Act and any proposal that has the potential to cause a significant impact on the populations or their critical developmental habitats must be referred to the Commonwealth Government. The knowledge provided by this study confirms the presence of these animals in Commonwealth waters around Norfolk Island and consequently any future environmental

impact assessments must consider the potential impacts of a proposal on marine turtles as part of the EPBC referral process.

CONCLUSIONS

This study comprises the first published report of resident foraging green and hawksbill turtles within the Norfolk Island group. Confirmed regular sightings of adult and juvenile green turtles and of adult hawksbill turtles at the island, in addition to the published records confirming the presence of food sources that are used by these species, support this conclusion. Until proven otherwise, we conclude that the lack of confirmed foraging records from more southerly waters around New Zealand or the Kermadec Islands suggest that Norfolk Island, along with Lord Howe Island, currently represent the southernmost recognised foraging habitat for green and hawksbill turtles in the south western Pacific region. The study results confirm that green and hawksbill turtles can live year round in waters that fall to a minimum of 18°C.

While the historical records report basking by green turtles at Norfolk, Balazs (1980) has shown that the presence of basking turtles does not automatically imply a beach is a rookery, and from this evidence, together with the restricted nesting sand area, shallow sand depths, cool sand temperatures and the lack of any evidence of eggs or nests either in the historical literature or modern day observations we conclude that Norfolk Island is not now, and has not been, a marine turtle rookery within the recorded history of this area. Furthermore the paucity of turtle remains in the island's Polynesian middens suggests that during the era of Polynesian visitation (>800 years BP) turtles were not a readily available food source. We recognise however that global warming could provide suitably warm enough beaches for turtle nesting to be successful in the future.

The natal rookeries for the resident green and hawksbill turtles have been inferred from large scale regional current movements and are

likely to include rookeries in the north eastern Australia, Melanesia and Polynesia regions. We believe hatchlings arriving at Norfolk Island from these rookeries are carried westward on the SEC before travelling south and east on the EAC and its associated eddies and currents.

The primary implication arising from this study confirming the presence of resident turtles foraging at Norfolk Island will be for future development proposals in Commonwealth waters around the Norfolk Island region. As listed and migratory species, the presence of marine turtles will trigger the EPBC Act and any proposed action must address the potential for impact on these species. Furthermore this information addresses a significant gap in the knowledge on marine turtles within the Commonwealth Government's East Marine Region Bioregional Plan.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable comments and feedback of our reviewers; Dr Kirstin Dobbs, Dr Colin Limpus, one anonymous reviewer and Paul Whittock for his comments and assistance with the figures. On Norfolk Island; Mr Les Q. Brown gave the authors access to his library of historical documents, Dr Bryan Gartrell DMV volunteered his time to do necropsies, and we are grateful to all the island residents who have taken the time and effort to report turtle strandings and sightings over the years.

LITERATURE CITED

Balazs, G.H. & Ellis, D.M. 2000. Satellite telemetry of migrant male and female green turtles breeding in the Hawaiian Islands *In*, Abreu-Grobois, F. A., Briseno-Duenas, R., Marquez, R., Sarti, L. Compilers, *Proceedings of the Eighteenth International Sea Turtle Symposium*. U.S. Department of Commerce. National Oceanographic and Atmospheric Administration (NOAA) *Technical Memorandum National Marine Fisheries Service (NMFS)*, South East Fisheries Science Center (SEFSC) **436**: 281-283

Balazs, G.H. 1980 Synopsis of Biological Data on the Green Turtle in the Hawaiian Islands. National Oceanographic and Atmospheric Administration

Technical Memorandum National Marine Fisheries Service, NOAA-TM-NMFS-SWFC-7

Bureau of Meteorology (BOM). 2011. Climate of Norfolk Island. <http://www.bom.gov.au/nsw/norfolk/climate.shtml>

Brewer, D.T., Flynn, A., Skewes, T.D., Corfield, J., Pearson, B., Alowa, J., & Young, J.W. 2007. *Ecosystems of the West Marine Planning Region*. Report to Department of Environment and Water Resources. (CSIRO: Cleveland) 150pp.

Brook, F.J. 1990. Geological origin and coral fauna of Kingston Lagoon. Pp 25-28 *In*, M.P. Francis, F.J. Brook, J.E. Randall, R. Cole, M.W. Williams, C. Ward, & M. Davis. *Norfolk Island fish survey, 11-26 November 1989*. Report to Australian National Parks and Wildlife Service.

Clark, Ralph, & Fidlon, Paul G. & Ryan, R. J. 1981. The journal and letters of Lt. Ralph Clark, 1787-1792 / edited by Paul G. Fidlon and R.J. Ryan Australian Documents Library in association with the Library of Australian History, Sydney.

1980. The Journal of Philip Gidley King: Lieutenant, R.N. 1787-1790. Australian Documents Library, Sydney.

Cresswell, G.R. 1989. The oceanography of Norfolk Island and the H.M.S. Sirius wreck site. 1988 expedition to report on the wreck of the H.M.S Sirius (1790). Report to Norfolk Island Government. *In*, Francis, M. P. 1993.

Department of Environment Water Heritage and the Arts (DEWHA) 2007a. Characterisation of the marine environment of the East Marine Region. A summary of the expert workshop convened in Brisbane, Queensland, 28-29 November 2007.

2007b. The East Marine Bioregional Plan. Bioregional Profile. A description of the Ecosystems, Conservation Values and Uses of the East Marine Region. 254 pp.

Francis, M.P. 1993. Checklist of the Coastal Fishes of Lord Howe, Norfolk, and Kermadec Islands, Southwest Pacific Ocean. *Pacific Science* **47**:(2) 136-170.

Garnett, S.T. & Murray, R.M. 1980. Farm Management and Nutrition of the Green Turtle (*Chelonia mydas*). 60-65, *In*: Banks, C.B. & Martin, A.A. *Proceedings of the Melbourne Herpetological Symposium May 19-21, 1980*. (Zoological Board of Victoria, The Royal Melbourne Zoological Gardens: Parkville) 3052 1981: I-Ix, 1-199

Gill, B.J. 1997. Records of turtles and sea-snakes in New Zealand, 1837-1996. *New Zealand Journal of Marine and Freshwater Research*. **31**(4): 477-486

Hirth, H. 1993. Marine turtles. Pp 329-370. *In*, Wright, A. & Hill, L. (eds) *Nearshore Marine*

- Resources of the South Pacific: Information for Fisheries Development and Management*. Inst. Pacific Studies (Suva), Forum Fisheries Agency (Honiara), International Center Ocean Development (Canada).
- Hoare, M. 1999. *Norfolk Island: A Revised and Enlarged History 1774 - 1998*. (Central Queensland University Press: Rockhampton).
- Hoggett, A.K., & Rowe, F.W.E. 1988 Zoogeography of echinoderms on the worlds most southern coral reefs. Pages 379-387. *In* R.D. Burke, P.V. Mladenov, P. Lambert, & Parsley, R.L. (eds.) *Echinoderm Biology: Proceedings of the Sixth International Echinoderm Conference*, Victoria, 23-28 August 1987.
- Hunter, J. 1793. *An Historical Journal of the Transactions at Port Jackson and Norfolk Island*. University of Sydney Library, 2003. <http://purl.library.usyd.edu.au/setis/id/huntran>.
- Jones J.G. & McDougall I. 1973. Geological History of Norfolk and Phillip Islands, Southwest Pacific Ocean. *Journal of the Geological Society of Australia* 20(3).
- Limpus, C.J. 1978. The reef: uncertain land of plenty. Pp 187-222 *In*, Lavery, H.J. (ed.) *Exploration North, A Natural History of Queensland*. (Richmond Hill Press: Richmond).
- Limpus, C.J. 1979. Notes On Growth Rates Of Wild Turtles. *Marine Turtle Newsletter* 10: 3-5.
- Limpus, C.J. 2008. *A Biological Review of Australian Marine Turtle Species*. Queensland Environmental Protection Agency.
- Limpus, C.J., Limpus, D.J., Arthurs, K.A., & Parmenter, C.J. 2005. Monitoring green turtle population dynamics in Shoalwater Bay: 2000-2004. *Great Barrier Reef Marine Park Authority Research Publication* 83: 1-51.
- McCann, C. 1966. The marine turtles and snakes occurring in New Zealand. *Record of the Dominion Museum* 5: 201-215.
- Millar, A.J.K. 1999. Marine Benthic Algae of Norfolk Island, South Pacific. *Australian Systematic Botany* 12(4): 479-547.
- Miller, J.D. & Limpus, C.J. 1981. Incubation Period and Sexual Differentiation in the Green Turtle *Chelonia mydas* L. Pp 66-73. *Illustr. In*, Banks, C.B. & Martin, A.A. *Proceedings of the Melbourne Herpetological Symposium* May 19-21, 1980. Zoological Board of Victoria, The Royal Melbourne Zoological Gardens, Parkville, Victoria (Dominion Press) 3052 1981: 1-IX, 1-199
- Miller, J.D. 1982. Embryology of Marine Turtles. Ph.D. dissertation, Department of Zoology, University of New England, Armidale, New South Wales, Australia; 1982, v. 1, 213 pp., v. 2, 248 pp.
- Miller, J.D. 1985. Embryology Of Marine Turtles *In*: Gans, C., Billett, F., Maderson, P.F.A., (Eds.); *Biology of the Reptilia*. Academic Press, New York; Volume 14, (Development A): 269-328
- Miller, J.D., Limpus, C.J. & Godfrey, M.H. 2003 Nest Site Selection, Oviposition, Eggs, Development, Hatching, and Emergence of Loggerhead Turtles. Pp 125-143 *In*, Bolten, A.B., Witherington, B.E. (eds.), *Loggerhead Sea Turtles*. (Smithsonian Books: Washington, D.C.).
- Nilson, C.S. & Cresswell, G.R. 1981. The formation and evolution of East Australian Current warm-core eddies. *Progress on Oceanography*. 9: 134-183.
- O'Hara, T.D. 2008. Bioregionalisation of the waters around Lord Howe and Norfolk Island using brittle stars (Echinodermata: Ophiuroidea). *Report to the Department of Environment and Heritage*. (Department of the Environment, Water, Heritage and Arts: Australia).
- Pritchard, P.C.H. 1982. Marine turtles of the south pacific. Pp: 253-262 *In*: Bjorndal, K.A. (ed.). *Biology and Conservation of Sea Turtles*. (Smithsonian Institution Press, Washington D.C.) 1982: 1-583
- Ridgeway, K. & Dunn, J.R. 2003. Mesoscale structure of the mean East Australian Current System and its relationship with topography. *Progress in Oceanography* 56(2): 189-222.
- Ridgeway, K. & Hill, K. 2009. The East Australian Current. *In*: A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009 Poloczanska, E.S., Hobday, A.J. & Richardson, A.J. (eds) National Climate Change Adaption Research Facility (NCCARF) Publication 05/09, ISBN 978-1-921609-03-9.
- Smith, I., Clark, G. & White, P. 2001. Mammalian and Reptilian Fauna from Emily and Cemetery Bays, Norfolk Island. *In*, The Prehistoric Archaeology of Norfolk Island, Southwest Pacific. Anderson, A. & White, P. (eds) *Records of the Australian Museum*, Supplement 27: 75-79.
- Trevor, A.P. 2010. Turtle Research and Monitoring Database System (TREDs) South Pacific Regional Environment Programme, Annual Report, 3 December 2009. (Apia: Samoa).
- Whittow, G.C. & Balazs, G.H. 1982. Basking behaviour of the Hawaiian green turtle (*Chelonia mydas*). *Pacific Science* 36(2): 129-139.
- Williams, A., Althaus, F. & Furlani, D. 2006a. Assessment of the Conservation Values of the Norfolk Seamounts Area. Report to the Department of Environment and Heritage.
- Williams, A., Althaus, F. & Gowlett-Holmes, K. (eds) 2006b. Ecosystems of the East Marine Region, NORFANZ Final report to the National Oceans Office. (CSIRO Marine Research: Hobart).