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Final Report

Nesting green turtles of Torres Strait

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Australian Government
Department of the Environment

Reef & Rainforest RESEARCH CENTRE

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Final report

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Executive Summary

1. Monitoring of nesting turtles at two Torres Strait rookeries has occurred since 2006. Dauar Island in the Mer group was monitored from 2006 to 2014 (except in 2011), and Maizub Kaur (Bramble Cay) has been monitored annually since 2007. Monitoring has followed the methods of the Queensland Government.

2. Both rookeries are part of the northern GBR/Torres Strait population of green turtles and both rookeries receive around 100 to 3,000 green turtles per year. Annual numbers of breeding turtles fluctuate similar to Raine Island.

3. Nesting success of female turtles at both rookeries is lower at the start of the nesting season when the sand is dry. Rainfall later in the season increases nesting success. In November/December nesting success is around 50% and within the expected range for female turtles nesting on coral cays.

4. More data are required to allow robust quantification of hatchling production however existing data indicate that both rookeries produce hatchlings at a rate of around 70%, which would be expected of a green turtle rookery.

5. Temperature monitoring demonstrates that Dauar Island will produce hatchlings with a female bias sex ratio.

6. Dauar Island is the only significant rookery for the population that has shade-generating vegetation and it is an elevated island making it important for the future of the population.

Introduction

The Islands in the Mer group (Mer, Dauar and Waer) and Bramble Cay are the most significant green turtle rookeries in Torres Strait and along with sites in the Great Barrier Reef are main sites for the Torres Strait /northern GBR genetic population. While there are long-term data sets for the rookeries in the GBR, little quantitative data exist for turtle rookeries in Torres Strait (Limpus et al. 2001, 2003). In December 2006 and 2007, we began annual nesting turtle research trips to Dauar Island and Bramble Cay respectively. Here we report results from annual trips until 2014.

Objectives

1. To calculate reproductive parameters for nesting green turtles at Dauar Island and Bramble Cay (size range, nesting success, mortality rates [of nesting turtles], egg production).
2. To determine factors influencing nesting success of sea turtles.

Methods

To calculate reproductive parameters for nesting green turtles at Dauar Island and Bramble Cay (size range, nesting success, mortality rates [of nesting turtles], egg production) the following methods were used.

Turtle nesting surveys

Turtle nesting surveys were conducted on Dauar Island (2006 to 2014, except 2011) and Bramble Cay (2007 to 2014) and these surveys followed the standard methods of the Queensland Department of Environment and Heritage Protection[1] (QDEHP) turtle conservation project. The timing of each trip coincided with the timing of QDEHP trips to Raine Island, thus allowing data comparisons. All tagging data has been entered to the QDEHP state wide relational database.

The number of turtles emerging each night at Dauar Island and Bramble Cay was calculated either by saturation tagging (in 2007, 2009, 2010 and 2012), by a combination of tagging and track counting (in 2006, 2008 and 2013) or a combination (in 2014). Track counts were conducted at the end of the night to determine the number of turtles that had emerged to nest. Two independent observers completed track counts and the average of the two counts was used. This number is likely to be an underestimate because turtles arriving later in the night covered some earlier tracks.

[1] http://www.ehp.qld.gov.au

Clutch disturbance

We calculated the clutch equivalent egg mortality using the methods of Limpus et al. (2003):

CEEM = (egg mortality per clutch disturbed * clutch disturbance)/mean clutch size

Nesting success (% of females ashore who lay eggs)

Two methods were used for calculating nest success: (1) in low density nesting seasons each turtle that comes ashore is monitored for whether she lays a clutch or returns without laying a clutch, and (2) in high density years a 50 m section of beach is monitored for 6 to 8 hours and each turtle that enters and leaves the sector is counted, as are the number of clutches laid.

Emergence success of clutches

We follow the techniques of Miller et al. (1999).

Factors that may influence nesting success

These were focussed on: (a) broad-scale indices of whether a beach was suitable for successful nesting (Temperature and Wind exposure), and (b) island-scale indices such as fine scale temperature variation, beach stability and vegetation.

Results

Nesting turtles: Number of turtles nesting per night

At Bramble Cay, only nesting by green turtles was recorded. At Dauar nesting hawksbill was recorded in 2012 and the rest were green turtles. The annual variation within sites matches variation in other green turtles rookeries along the Queensland coast as presented in Tables 1 (turtles tagged and tagging history), 2, 3 and Figure 1 (numbers ashore for nesting each night).

Table 1. Number of nesting green turtles tagged between 2006 and 2013 at Dauar and Bramble Cay.

Location & year	Number of new turtles tagged	Number initially tagged in previous years return to same beach	Number initially tagged in previous years return to different beach	Number tagged in same year from different beach	Number first tagged at foraging sites
Dauar06	200	0	0	0	1
Dauar07	10	0	0	0	0
Dauar08	240	0	1	0	0
Dauar09	58	0	0	0	1
Dauar10	167	0	0	0	0
Dauar12	6	0	0	0	0
Dauar13	152	7	1 (Bramble 09)	0	0
Dauar14	116				
Bramble07	20	0	0	0	0
Bramble08	220	0	0	0	0
Bramble09	93	0	0	0	1
Bramble10	148	0	0	3 (Dauar)	1
Bramble11	204	0	0	0	0
Bramble12	74	5	0	0	0
Bramble13	260	17	1 (Dauar 08)	0	0
Bramble14	211				

Table 2. Average number of female green turtles that came ashore to nest each night for the sampling period at Dauar or Waer Island (standardised counts for north beach only – north beach is 64% of total island nesting based on data from 2006 to 2008 when all beaches were monitored).

Location	Year	Days	Number tracks/females per night	Type of count census
Dauar Island	2006	6	800 – tracks	Walking tally & track count
Dauar Island	2007	6	10 – females	Total observed females
Dauar Island	2008	6	250 – tracks	Walking tally & track count
Dauar Island	2009	5	5 – females	Total observed females
Dauar Island	2010	4	42 – females	Total observed females
Dauar Island	2012	3	2 – females	Total observed females
Dauar Island	2013	4	319 – tracks	Track count
Dauar Island	2014	3	89 - tracks	Track counts + tagging census

Table 3. Average number of female green turtles that came ashore to nest each night for the sampling period at Bramble Cay.

Location	Year	Days	Number tracks/females per night	Type of count census
Bramble Cay	2007	3	9 – females	Total observed females
Bramble Cay	2008	3	216 – tracks	Walking tally & track count
Bramble Cay	2009	4	25 – females	Total observed females
Bramble Cay	2010	3	74 – females	Total observed females
Bramble Cay	2011	2	118 – females	Total observed females
Bramble Cay	2012	4	19 – females	Total observed females
Bramble Cay	2013	4	467 – tracks	Track count
Bramble Cay	2014	3	161 - females	Track counts + tagging census

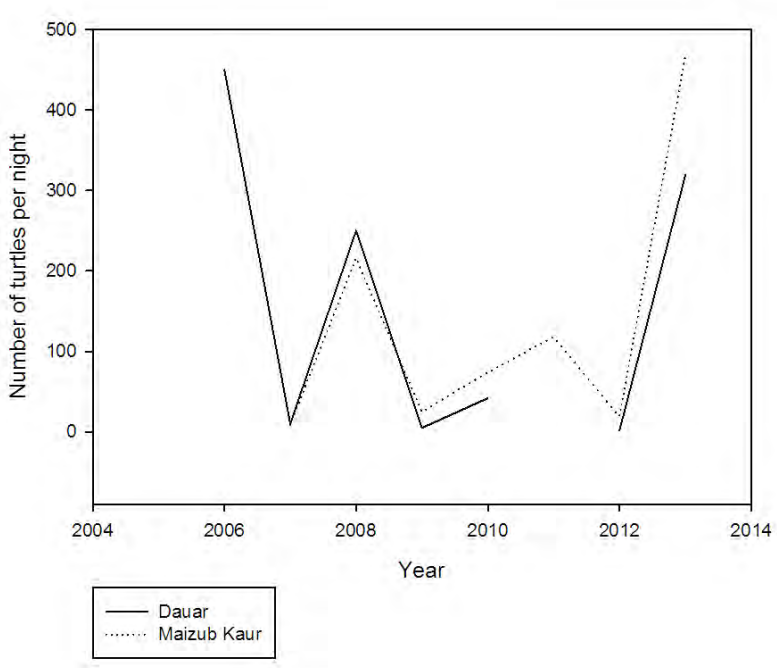

Figure 1. Annual variation in the average (yearly) nightly numbers of female green turtles recorded ashore at Torres Strait rookeries.

Nesting success of females

The overall nesting success at Dauar Island and Bramble Cay from 2006 to 2014 (% of female turtles that emerge each night the lay eggs) is provided in Tables 1 to 4. Essentially, nesting success at a beach level ranged from <10% up to >60% between nights and the mean island values ranged from 25% to 68% at Dauar (Tables 4 to 10), 18% to 60% at Bramble Cay (Table 11).

Table 4. Nightly nesting success for green turtles nesting in a monitored 50 m sector on the southern and western beaches of Dauar Island in December 2006 and February 2007.

Date	Beach name	Number of turtles	Number of successful nests laid	Nesting success %
29 Nov 2006	South	109	24	22
	West	75	8	10
30 Nov 2006	South	92	22	24
	West	52	5	10
1 Dec 2006	South	108	52	48
	West	37	5	13
2 Dec 2006	South	176	41	23
	West	51	10	20
4 Dec 2006	South	140	62	44
29 Jan 2007	South	62	25	40
20 Jan 2007	South	42	24	57
31 Jan 2007	South	70	38	54
1 Feb 2007	South	51	35	68
2 Feb 2007	West	39	3	7
3 Feb 2007	South	61	34	56
MEAN	SOUTH			44%
MEAN	WEST			12%
MEAN	ALL			33%

Table 5. The number of green turtles emerging to nest and successfully laying a clutch of eggs each night on the north beach of Dauar Island, 2007.

Date	Beach	Number of turtles ashore	Number of nests laid	% nest success
30 Nov 2007	North	3	2	66
1 Dec 2007	North	3	2	66
2 Dec 2007	North	6	2	33
3 Dec2007	North	7	5	71
4 Dec 2007	North	4	2	50
5 Dec 2007	North	6	3	50
6 Dec 2007	North	5	3	60
MEAN	NORTH			57
MEAN	ALL			62

Table 6. Nightly nesting success for green turtles nesting in a monitored 50m sector on the southern and northern beaches at Dauar Island in 2008.

Date	Beach	Number of turtles in sector	Number of nests laid	% nest success
23 Nov	South	23	13	56
24 Nov	South	30	-	-
	North	25	20	80
25 Nov	South	10	7	70
	North	24	-	-
26 Nov	South	26	4	15
	North	74	61	82
27 Nov	North	55	-	-
MEAN	SOUTH			47
MEAN	NORTH			81
MEAN	ALL			60

Table 7. The number of green turtles emerging to nest and successfully laying a clutch of eggs on one night of the survey period at Dauar Island, 2009.

Date	Beach	Number of turtles ashore	Number of nests laid	% nest success
1 Dec	South	10	6	60%

Table 8. The number of green turtles emerging to nest and successfully laying a clutch of eggs each night on Dauar Island, 2010.

Date	Beach	Number of turtles ashore	Number of nests laid	% nest success
29 Nov	North	60	31	52%
30 Nov	North	64	27	42%
1 Dec	North	26	21	81%
2 Dec	North	19	18	95%
MEAN				68%

Table 9. The number of green turtles emerging to nest and successfully laying a clutch of eggs each night on Dauar Island, 2012.

Date	Beach	Number of turtles ashore	Number of nests laid	% nest success
27 Nov	North	1	0	0%
28 Nov	North	4	3	75%
29 Dec	North	1	0	0%
MEAN				25%

Table 10. The number of female turtles emerging to nest each night on Dauar Island in 2013. Note that no monitored area was set aside in this year and numbers of turtles and successful nests were based on walk around track counts.

Date	Beach	Number of turtles ashore	Number of nests laid	% nest success
27 Nov	North	274	131	48%
28 Nov	North	357	65	18%
29 Dec	North	327	91	28%
MEAN				31%

Table 11. The number of green turtles emerging to nest and successfully laying a clutch of eggs for sampling nights at Bramble Cay between 2007 and 2013.

Date	Number of turtles	Number of nests laid	% nest success	Notes
2007	20	12	60%	All turtles ashore
3 Dec 2008	34	18	53%	50m sector
9 Dec 2009	35	17	48%	All turtles ashore
10 Dec 2009	34	13	86%	All turtles ashore
3 Dec 2010	16	7	44%	50m sector
5 Dec 2012	28	9	32%	All turtles ashore
5 Dec 2013	335	59	18%	Determined by walk around count
MEAN			49%	

In 2014 the nesting success was 13% (11 to 15) at Dauar and 27% (21 to 32) at Bramble Cay.

Size (Curved carapace length) of nesting females

Table 12. Mean annual curved carapace length of female green turtles ashore nesting at Dauar (no survey was conducted in 2011).

Year	Mean CCL	Standard Dev	Number
2006	104.2	5.0	
2007	102.7	2.8	10
2008	104.3	4.4	
2009	105.9	4.4	57
2010	104.2	4.5	162
2012	105.2	4.3	6
2013	103.4	4.0	152
2014	104.1		116

Table 13. Mean annual curved carapace length of female green turtles ashore nesting at Bramble Cay, 2007 to 2014 * 1979 data from Limpus et al. (2001).

Year	Mean CCL	Standard Dev	Number
1979*	105.9	4.8	681
2007	108.2	4.5	22
2008	104.5	5.1	220
2009	105.7	5.3	92
2010	104.2	4.3	149
2011	103.7	4.8	204
2012	104.5	4.5	
2013	103.6	4.5	
2014	105.5		211

With the exception of the 2007 data from Bramble Cay, these annual mean CCLs are each smaller than turtles recorded nesting at Bramble Cay in 1979 (Limpus et al. 2001). Furthermore, the mean lengths at Dauar Island in each of the years, and Bramble Cay in 2008 are lower than most seasonal means recorded at Raine Island between 1976 and 2001 (Limpus et al. 2003).

Nest excavation

Twenty five nests were excavated at Dauar Island in 2006/2007. No emerging nests were found in 2007/2008. The mean emergence success in 2006/2007 was 64.6 ± 32.8% (range 0 to 98.8). However, preliminary data indicate that inter- and intra- beach variation is likely (Figure 1, where: n = 2 [East open light], n = 9 [south open light], n = 8 [south shade dark] and n = 6 [west open dark]). During the December visits to Dauar Island each year, hatchlings were seen dispersing across the beach on most nights.

Migration recaptures

In 2008, two turtles were recaptured that had been tagged as part of another turtle tagging project. One female was tagged while nesting at Milman Island in 2001. This represents an inter-annual change of rookery of approximately 150 km. The second turtle was tagged by Queensland Government researchers in the northern GBR during a foraging area trip.

Clutch disturbance

In each year, <1% of clutches laid were disturbed by other nesting turtles at either Dauar Island or Bramble Cay.

Egg and hatchling predation

At Dauar Island in 2008, we witnessed predation of one clutch of incubating eggs by goannas (Varanus indicus). No predation of eggs or hatchlings was observed in other years.

Beach temperature records

Data loggers have been deployed for various intervals from 2006/2007 at several of the key islands for green turtles to record beach sand temperatures (Table 14). The most recent detailed analysis of these data (Fuentes et al. 2009, 2010) used data from common collection periods to indicate that sand temperature was significantly different across the various rookeries (One way ANOVA, $p< 0.00$, $df = 11$, $f = 221.888$), with the west-facing beach at Milman Island having the coolest temperatures and the north-facing beach at Dauar Island having the warmest temperatures. Data from 2006 to 2013 indicate that the beaches at Dauar Island are producing mainly female hatchlings (Figure 2).

Table 14. Locations and durations of sand temperature data collection 2006 to 2013.

Island name	Years obtained	References
Dauar Island N	2006 to 2013	Fuentes et al. 2009; Fuentes & Hamann unpublished
Dauar Island S	2006 to 2013	Fuentes et al. 2009; Fuentes & Hamann unpublished
Bramble Cay	2007/2008	Fuentes et al. 2009
Milman Island	2005/2006 2007/2008	Ian Bell QPWS; Fuentes et al. 2009
Raine Island	2007/2008	Fuentes et al. 2009
Moulter Cay	2007/2008	Fuentes et al. 2009
Sandbank 7	2007/2008	Fuentes et al. 2009
Sandbank 8	2007/2008	Fuentes et al. 2009
Boydong & Bewick Islands	2010 to 2012	Fuentes & Hamann unpublished
Sir Charles Hardy	2008 to 2011	Fuentes & Hamann unpublished

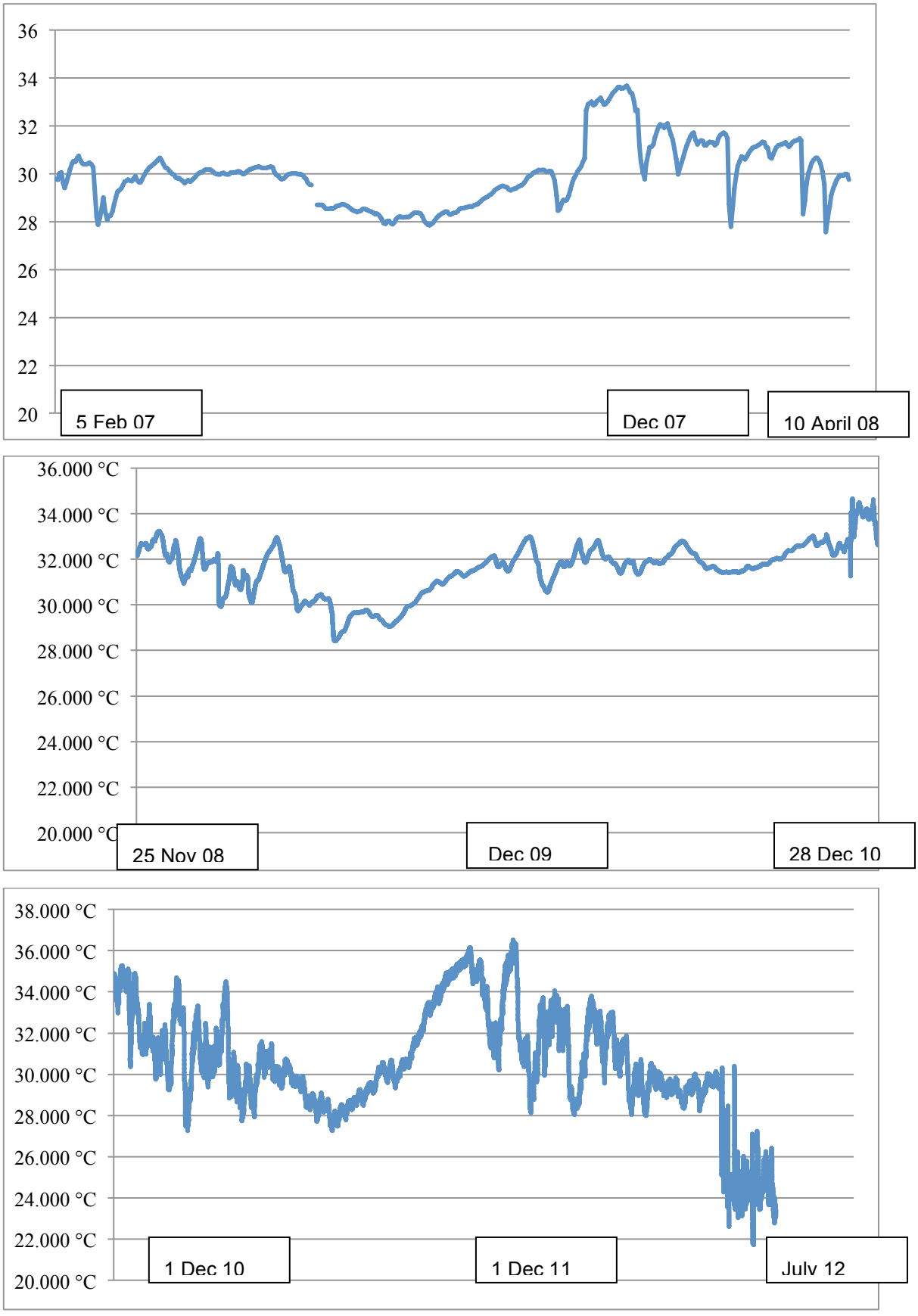

Figure 2. Mean daily sand temperature at 50 cm depth on the northern beach at Dauar Island 2007 and 2008 (top panel), 2008 to 2010 (middle panel), 2011 and 2012 (bottom panel).

Monitoring of beach sand temperatures indicates that:

- By 2030, under a conservative scenario of global warming, some males will be produced at the shaded areas at south Dauar Island and north Milman Island, south and west Milman Island and Sandbank 7 and under an extreme climate scenario males will only be produced at west Milman Island and south Sandbank 7.
- By 2070, under a conservative scenario of global warming, only west Milman Island and south Sandbank 7 will experience temperatures that produce males, and under an extreme climate scenario no rookery will produce male hatchlings.

Discussion

There are seven main rookeries used by turtles of the northern GBR and Torres Strait green turtle population. Regular and semi-regular data exist for four of these rookeries (Raine Island, Moulter Cay and Sandbanks 7 and 8) and a comprehensive assessment is provided in Limpus et al. (2003). In addition, there are data from the late 1970s and occasional brief surveys for Bramble Cay (see Limpus et al. 2001, 2003) and green turtle data has been collected opportunistically during hawksbill turtle surveys at Milman Island. The Islands of the Mer group represent the only major 'non coral cay' nesting habitat for the population. Our study, starting in 2006, represents the first quantitative assessment of the Dauar Island green turtle rookery.

One of the key threats that have been identified for green turtles in the northern GBR/Torres Strait population is poor ability of females to dig nesting sites and successfully lay eggs. Indeed, at Raine Island the percentage of nesting success is generally very low and in recent years has been regularly less than 10% (Limpus et al. 2003, Col Limpus pers comm). At Dauar and Bramble Cay, we recorded variable nesting success among the beaches and across seasons, and at Dauar Island it was always within the range of expected values for a marine turtle rookery. While nesting success at Dauar Island and Bramble Cay was higher than recent records from Raine Island it remained lower than green turtle rookeries in the southern GBR. Another issue reported in 1979, for which we have no recent data is the loss of clutches at Bramble Cay at the end of the season when the cay changes shape. This warrants further research.

Future research directions should include:

- Examining nest site selection (using Dauar and Milman Island data),
- Modelling of green turtle trend data using Milman Island as an reference site,
- Sediment budgets (Raine Island and Bramble Cay),
- Examination of recruitment (at all sites),
- Hatchling production (as many sites as possible), and
- Examining juvenile recruitment.

Climate change: Beach sand temperatures

Sand temperatures varied greatly between and within the nesting grounds used by the northern Great Barrier Reef green turtle population, with open areas in the sand dune at northern facing beaches being the warmest incubating environments. North-facing beaches receive more solar radiation than beaches at other orientations and consequently are warmer. Variation in intra- and inter-beach sand temperature ensures that eggs are incubated within a wider thermal range and both male and female hatchlings are produced to sustain turtle populations. Even though, the nesting grounds used by the northern GBR green turtle population experience both male and female producing temperatures, our results suggest a bias towards female hatchling production into this population. Indeed, a female bias has been commonly reported for different marine turtle species and nesting grounds with populations appearing to function successfully with 1:2 or 1:3 male to female ratio and it is not known what sex ratio can be sustained long term (Hamann et al. 2007). Dauar Island is a warm beach producing mainly female hatchlings, however it is an elevated rookery and the only rookery with shade-generating vegetation.

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