Monitoring of Coastal Sea Turtles: Gap Analysis

3. Hawksbill turtle, *Eretmochelys imbricata*, in the Port Curtis and Port Alma region

C.J. Limpus, C.J. Parmenter, and M. Chaloupka

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This report has been produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program. The study was undertaken under a Consultancy Agreement (CA120021) between Gladstone Ports Corporation and the Department of Environment and Heritage Protection to review all relevant literature on marine turtles for the Port Curtis and Port Alma regions.

This publication has been compiled by the Queensland Department of Environment and Heritage Protection (EHP).

Background

This study has been undertaken to provide a review and summary of available scientific literature and data on marine turtles in Central Queensland, particularly the Port Curtis and Port Alma region, and if required, expand the extent to consider turtle information for Queensland:

- Identify and update baseline data for suitable turtle habitat in the Port Curtis and Port Alma region at a distance of 500km north of Port Alma and south of Port Curtis
- Assess whether the available historical survey data are sufficiently robust to permit trend analyses. If so, undertake a trend analysis; undertake a formal power analysis of the reviewed data, if appropriate;
- Conduct a quantitative analysis of the historical trends in marine turtle numbers for the Port Curtis and Port Alma region; and
- Identify the migratory links between resident foraging turtles in the Port Curtis and Port Alma region and their nesting areas.

The hawksbill turtle, *Eretmochelys imbricata* (Figure 1), has a global distribution, occurring in all oceans. The biology and conservation status of hawksbill turtles has been reviewed at a global scale by Parsons, 1972; Witzell (1983) and Meylan and Donnelly (1999) and in Australia by Limpus (2009).

This species was once very abundant but has been severely depleted by excessive harvest of the turtles for the scales on the carapace (tortoiseshell) and of their eggs (Anon, 2004; Meylan and Donnelly, 1999). The hawksbill turtle has abundant nesting and foraging populations in Queensland, supporting one of the largest remaining populations in the world (Limpus, 2009).

Status

Within Australia, the hawksbill turtle is scheduled as a vulnerable species under both the Queensland and Federal conservation legislation and associated regulations, *Nature Conservation Act 1992* and *Environment Protection and Biodiversity Conservation Act 1999*, respectively.

Data sources

This gap analysis has drawn on information available in the published literature and in the two primary computerised data bases with the Queensland Department of Environment and Heritage Protection (EHP).

Queensland Turtle Conservation (QTC) database

EHP maintains a database that incorporates all tagging records for Queensland, incidental sighting records, nesting distribution and migration data for marine turtles in Queensland.

StrandNet

EHP maintains a database collating reports of sick, injured and dead marine wildlife (Cetaceans, dugong, turtles, threatened sharks and grouper) in Queensland (Biddle and Limpus, 2011). This data base includes turtle mortality from the Queensland Shark Safety Program.

These data sets have been supplemented with data sets managed by Dr Limpus which summarise international nesting and migration.

Index study sites

Nesting:

There is one index nesting beach for monitoring hawksbill turtle breeding in eastern Australia (Dobbs *et al*. 1999; Limpus, 2008)

- Milman Island (11.167^{o}S, 143.017^{o}E); total nightly tagging censes for a month during mid January to mid February, during most years 1991-2010.

Foraging

There have been several index foraging areas for monitoring hawksbill populations in eastern Australia (Limpus and Miller, 2008).

- Northern Great Barrier Reef (GBR) - Clack Reef (14.067^{o}S; 144.250^{o}E); annual tagging-recapture sampling of the foraging population during 1988-1991, 1997; discontinued index site because of low annual capture rate.
- Northern GBR - Howick Group reefs (14.500^{o}S, 144.983^{o}E); annual tagging-recapture sampling of the foraging population during 1997-2008.

- Southern GBR - Heron & Wistari Reef (23.433^{o}S, 151.917^{o}E); annual tagging-recapture sampling of the foraging population during 1984-1999.
- Moreton Bay (27.35^{o}S, 153.40^{o}E); annual tagging-recapture sampling of this small foraging population in temperate waters during 1990-2012.

Nesting population
A globally significant hawksbill turtle population breeds in the northern GBR and Torres Strait (Limpus *et al*. 2008): This nesting occurs commonly on the islands along the inner shelf of the Great Barrier Reef north of Princess Charlotte Bay, central and western Torres Strait and the mainland beaches of north-western Cape York Peninsula (Figure 2).

There have been only rare records of breeding by hawksbill turtles in eastern Australia south of Princess Charlotte Bay:
- a single clutch of hatchlings recorded from Linderman Island, Whitsunday Group, in 1929 (Limpus, 1985);
- an emerging clutch of hatchlings on Rocky Island (14.233^{o}S, 144.350^{o}E).

No hawksbill turtle nesting has been recorded within the 500km radius area of interest around Port Alma and Port Curtis.

Stock identification
The hawksbill turtle nesting population of north Queensland (northern GBR, Torres Strait) and eastern Arnhem land (Figure 2) has been identified as an independent management unit (genetic stock) when compared to the hawksbill turtle nesting populations of the eastern Coral Sea and Western Australia (Broderick *et al*. 1994; Dutton *et al*. 2002).

Limpus (2009) has hypothesised that the hawksbill turtles nesting in northern GBR/ Torres Straight should be a different stock to those nesting in eastern Arnhem Land because of differences in breeding seasonality and hence probable reproductive isolation. Resolution of this stock identification awaits reanalysis of the tissue samples using the more recent genetic methodologies.

Migration
Figure 3 summarises the data available for hawksbill turtle migration in the south-western Pacific Ocean, based on flipper tag recoveries and some satellite telemetry tracking data. These data indicate that hawksbill turtles foraging in the 500 km radius area of interest surrounding Port Alma and Port Curtis are most likely to originate from the nesting populations in eastern Papua New Guinea, Solomon Islands or Vanuatu. There is a low probability that the foraging hawksbill turtles of central Queensland will migrate to breed at nesting beaches in the northern GBR.

Broderick et al (1994) recorded MtDNA genotypes among foraging hawksbill turtles in the southern GBR off sore from Gladstone that was not identified among the genotypes identified to any nesting area genetically assessed at this time.

Oceanic pelagic post-hatchling dispersal
Hatchling hawksbill turtles disperse from their natal beaches to largely undescribed destinations. There is no evidence that hawksbill turtles between the size of hatchlings and curved carapace length (CCL) < 30 cm inhabit coastal habitats in eastern Australia (Limpus *et al*. 2008). There are sparse data indicating that these post-hatchlings occur in oceanic pelagic waters of the Coral Sea feeding on macro-plankton (Limpus and Limpus, 2008). However, there are also limited observations indicating that some hawksbill turtles up to adult size also forage in these oceanic waters of the Coral Sea (Robins *et al*. 2002). This is the most poorly understood phase in the hawksbill turtle life history.

Coastal foraging population
Limpus *et al*. (2008) have summarised habitat use by hawksbill turtles in eastern Australia: "…living across a diverse range of habitat conditions that extend from the clear waters at the detached reefs adjacent to the eastern margin of the GBR ……to reefs in inshore turbid waters near the mainland….. They inhabit tropical coral reefs from Torres Strait (9^{o}S) in the north to rocky reefs in temperate waters as far south as the Solitary Islands (30^{o}S) in northern New South Wales. While they have been most frequently encountered living on hard structured habitats such as coral and rocky reefs, they also occur at low density in open seagrass pastures." Hawksbill turtles also forage in the deeper soft

bottom habitats between the coral reefs of the GBR and the mainland and have been most frequently trawled at 11-25 m depth and less frequently to depths up to 45 m (Robins and Mayer, 1998).

Hawksbill turtles recruit from their oceanic pelagic post-hatchling dispersal phase at about 5-7 yr of age and CCL = 36.3 cm (SD = 2.715, range = 32.2 – 41.8 cm, n = 24. Limpus and Limpus, 2008).

Foraging populations in coastal waters through out eastern Queensland are consistently strongly biased to female across all age classes (male to female ratio between 1:2 and 1:3) except in the 11°S latitude block where the adult population only is biased to males (male to female ratio approximately 2:1) (Limpus *et al*. 2008).

Limpus *et al*. (2008) summarised the size and maturity of foraging hawksbill turtles "in three large regional samples of foraging from the Milman Island area (latitude 11°S block), Princess Charlotte Bay area (latitude 14°S block) and the Heron Island area (latitude 23°S block), sampling multiple reefs sampled across multiple years within each latitude block using similar capture techniques.

In the northern GBR:

- in the 11° latitudinal block, the size of captured turtles ranged from small immatures with CCL = 33.5 cm to adults with CCL = 90.0 cm. Large immature and adult turtles dominated the sampled population.
- in the 14° latitudinal block, the size of captured turtles ranged from small immatures with CCL = 36.7 cm to adults with CCL = 94.6 cm. Large immature and adult turtles dominated the sampled population.

In the southern GBR:

- in the 23° latitudinal block, the size of captured turtles ranged from small immatures with CCL = 32.2 cm to adults with CCL = 91.8 cm. The population was strongly dominated by immature turtles with comparable representation across the complete range of immature size classes upwards from recently recruited immature turtles. This result is very similar to the results of previous studies in the same area (Limpus 1992).

Each of these areas supports a hawksbill turtle population that is structured differently. When the total capture set for the entire eastern Queensland coast is examined, there was a consistent high representation of adult turtles in the samples obtained from the far northern GBR (11°–14° blocks) and a low proportion of adults within the sampled populations along the remainder of the coast to the south (Figure 8.2). This trend applies to both sexes."

Hawksbill turtles are slow growing. In southern GBR coral reef habitats (23°S), hawksbill turtles growth rates were modelled for data from 44 immature turtles for both female and male hawksbills ranging CCL = 39-85 cm, recorded during 1974-1991, using nonparametric regression methods (Chaloupka and Limpus, 1997):

- Immature female hawksbills grew at ~0.5 cm/ yr faster than male immature hawksbills at all recorded sizes.
- The mean-size specific growth rate function for both sexes was non-monotonic, rising rapidly from recruitment at CCL > 35 cm to a maximum growth rate of 2.2 cm/yr at CCL = 60 cm before declining to negligible growth approaching sexual maturity at CCL ≥ 80 cm for females and rising from the same recruitment size to a maximum growth rate of 1.7 cm/yr at CCL = 60 cm before declining to negligible growth with approaching sexual maturity at CCL ≥ 80 cm for males.
- Juvenile hawksbill growth spurts at CCL = ~60 cm, sex-specific growth and slow size-specific growth rates characterise growth for immature hawksbill turtles resident in southern GBR.

These results are supported by the analysis of a larger sample of growth data from the same study area (Limpus and Choy, 2008).

A comparable growth study of hawksbill turtles foraging in the northern GBR (14°S) modelling data from 128 turtles for both female and male hawksbills ranging CCL = 61-91 cm, recorded during 1997-2008 using nonparametric regression methods (Bell and Pike, 2012) concluded:

- annual growth rates did not differ between sexes;
- Growth pattern is non-monotonic;
- Growth peaks for both sexes within CCL = 65-70 cm range.
- Growth slowed thereafter at a linear rate, to negligible growth upon reaching an adult size, CCL > 80 cm;

- Hawksbill turtles grew faster in the southern GBR, compared to those found in the far northern GBR.

Miller *et al*. (2008) quantified the size at which hawksbill turtles recruit to the breeding population as first time breeding adults:

Females:

- Adult female hawksbill turtle breeding at Milman Island in the northern GBR commence breeding at mean CCL = 80.2 cm (SD = 3.104, range = 74.6 – 85.0 cm, n = 33).
- Adult females recorded at foraging areas within the GBR commence breeding at:
    - mean CCL = 82.7 cm (SD = 4.193, range = 79.3 – 90.4 cm, n = 6. based on gonad examination);
    - mean CCL = 83.9 cm (based on estimated size at which 50% of females are adult).

Males:

- Adult males recorded at foraging areas within the GBR commence breeding at:
    - Mean CCL = 80.6 cm (based on estimated size at which 50% of males are adult).

Adult females, on average, were larger than adult males at first breeding.

Limpus and Choy (2008) estimated the age at first breeding for hawksbill turtles foraging in the southern GBR using modelling of tagging-recapture growth data:

- Females – 31-36 years of age (95% confidence limits: ~20 yr – many decades);
- Males – about 38 years of age (95% confidence limits: ~23 yr – many decades).

Bell *et al*. (2012) reported on an 8 yr study of hawksbill turtle foraging abundance on 13 reefs in the Howick Group (14ºS) in the northern GBR based on a Cormack–Jolly–Seber analysis of 665 tagging-recapture records:

- Mean annual population estimates were consistently greater for adult female hawksbill turtles (n = 333.7; SD = 135.6; range = 221–581) than for adult males (n = 32.4; SD = 33.4; range = 8–98),
- Adult males and females displayed high annual survivorship rates (71.1%; 92.2%, respectively).
- Immature male and female turtles showed similarly high survivorship likelihoods (78.0%; 93.0%, respectively).

These tagging-recapture studies in the southern GBR coral reef (Chaloupka and Limpus, 1997; Limpus and Choy, 2008) and in the northern GBR (Bell and Pike, 2012; Bell *et al*. 2012) demonstrate that hawksbill turtles display a strong fidelity to their respective coastal foraging areas. However, Limpus *et al*. (2008) discuss evidence in support of the hypothesis for northward developmental migration of hawksbill turtles as they mature – even though this hypothesis is not supported by tag recovery data.

Hawksbill turtles have been recorded within the port limits of Port Alma and Port Curtis (Figure 4). However, no studies have been conducted with this species with the port limits.

Hawksbill turtles stranding through out eastern Queensland are dominated by the size class (Figure 5) that characterises hawksbill turtles as they recruit from open ocean pelagic dispersal to coastal benthic foraging. There are insufficient data to determine whether the mortality is dependent on the health of the turtles within the oceanic environment or whether it results from environmental conditions in coastal waters. A rigorous pathology investigation of these turtle is required to determine the cause of mortality at this change in life-history phase.

Diet

There has been no detailed study of the diet of hawksbill turtles in eastern Australia. The species has been reported to feed on algae and sponges in Fogg Bay, western Northern Territory (Whiting, 2000) and on algae, seagrass and sponges on the reefs at Cocos Islands (Whiting, 2004). These results indicate that hawksbill turtles are not primarily spongivores as is reported in some studies in the Atlantic Ocean. (Van Dam and Diez, 1997). Obura *et al*. (2010) reported hawksbill turtles were significant predators on Bubble corals.

Trends

Nesting census data are available for Milman Island during the decade, 1990-1999. The nesting population at this index beach was declining at 3-4% per year (Miller *et al*. 2008). In the absence of

additional data, this result is taken as indicative of the trend in hawksbill turtle nesting population within north Queensland.

Bell *et al*. (2012) reported on an 8 yr study of hawksbill turtle foraging abundance on 13 reefs in the Howick Group (14ºS) in the northern GBR based on a Cormack–Jolly–Seber analysis of 665 tagging-recapture records:

- Both sexes exhibited a similar overall trend with a peak population density being displayed in the first two years of the study, followed by a general decline among females while the male population remained stable.

This result is consistent with the potential decline in adult females resident in the GBR resulting from the killing of these turtles when they migrate to breed in neighbouring countries (Limpus and Miller, 2008). Until additional studies are reported, it is presumed that the declining adult female population reported for the Howick Group, northern GBR is applicable to the GBR as a whole.

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A. Adult sized and recently recruited immature hawksbill turtles caught on Heron island Reef, 1995.

B. Hatchling hawksbill turtle

Figure 1. Hawksbill turtle, *Eretmochelys imbricata*, in northern Australia.

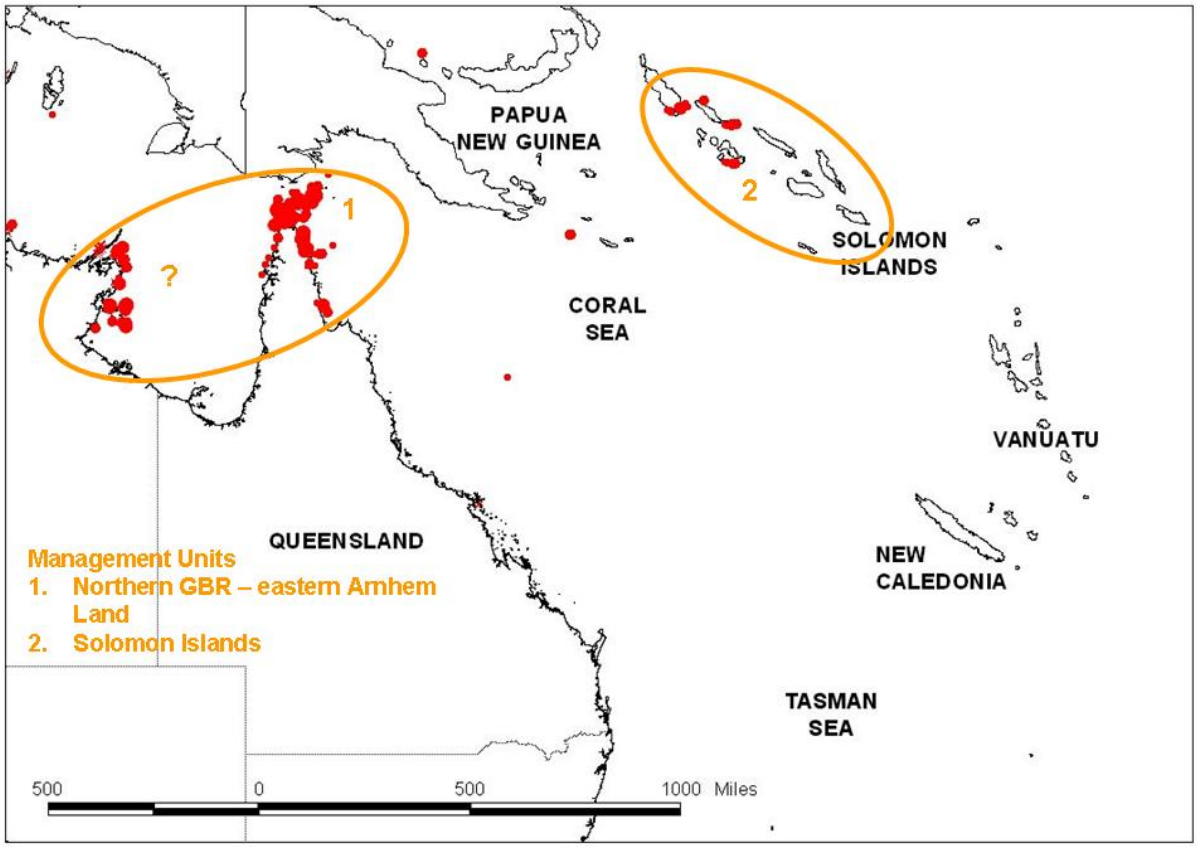
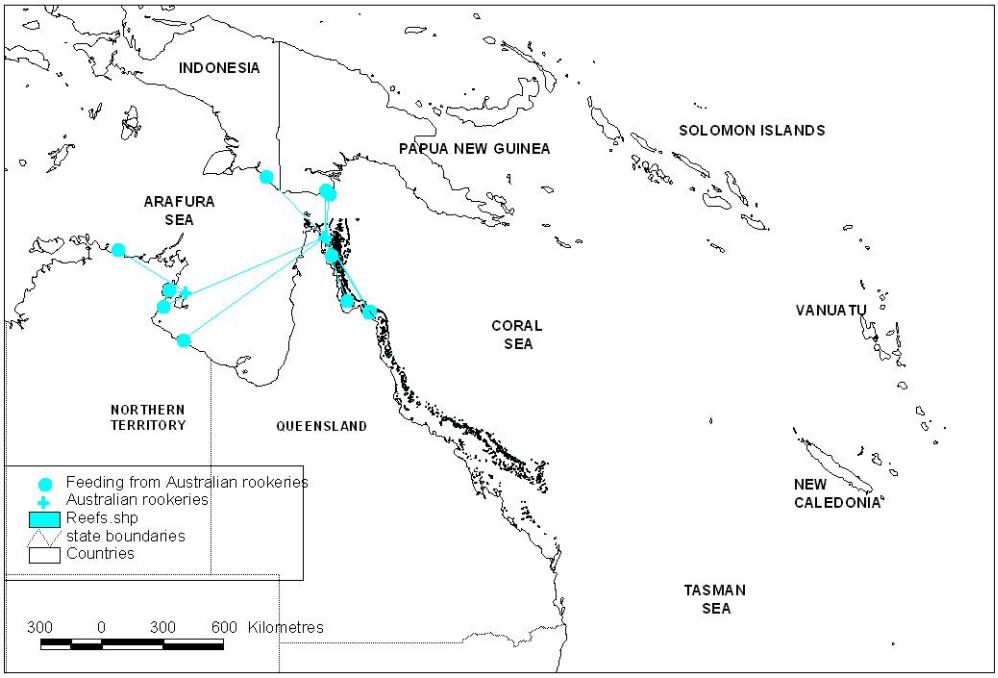
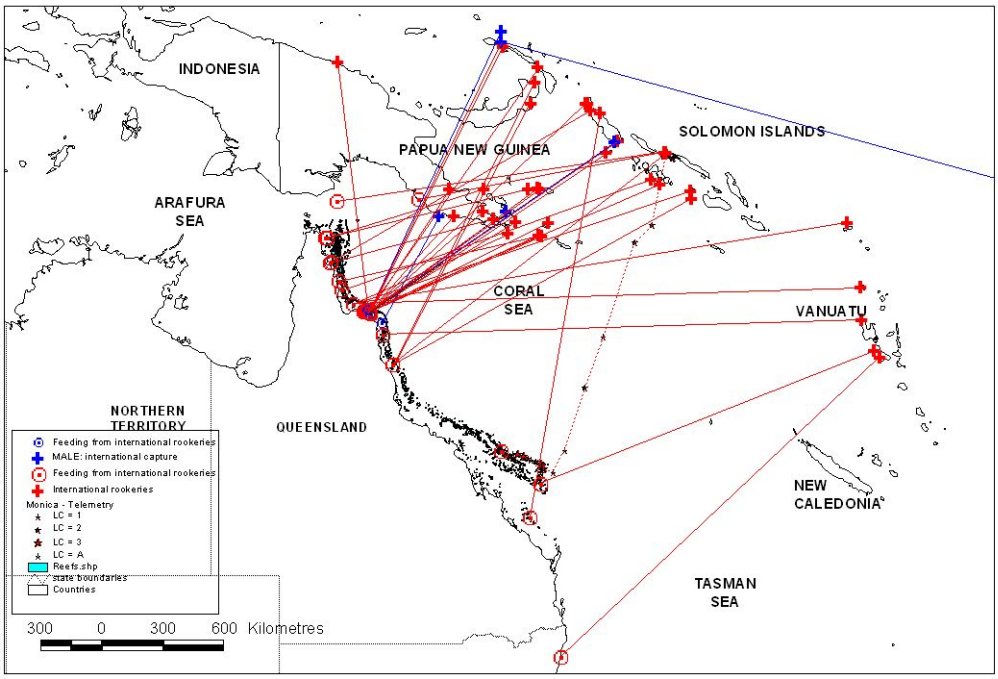


Figure 2. Hawksbill turtle, *Eretmochelys imbricata*, nesting distribution by management units (genetic stocks) in eastern and northern Australia. Red dots denote recorded nesting localities.



A. Migration to/from breeding areas within Australia (flipper tags: n=9 females. Satellite telemetry: n=2).



B. Migration to/from breeding areas outside of Australia (flipper tags: n=33 females; n=5 males. Satellite telemetry: n=1 female).

Figure 3. Migration of adult hawksbill turtles, *Eretmochelys imbricata*, between breeding areas (crosses) and foraging areas (circles) based on flipper tag recoveries and satellite telemetry. Straight lines do not depict migratory pathways but link the respective foraging and breeding sites.

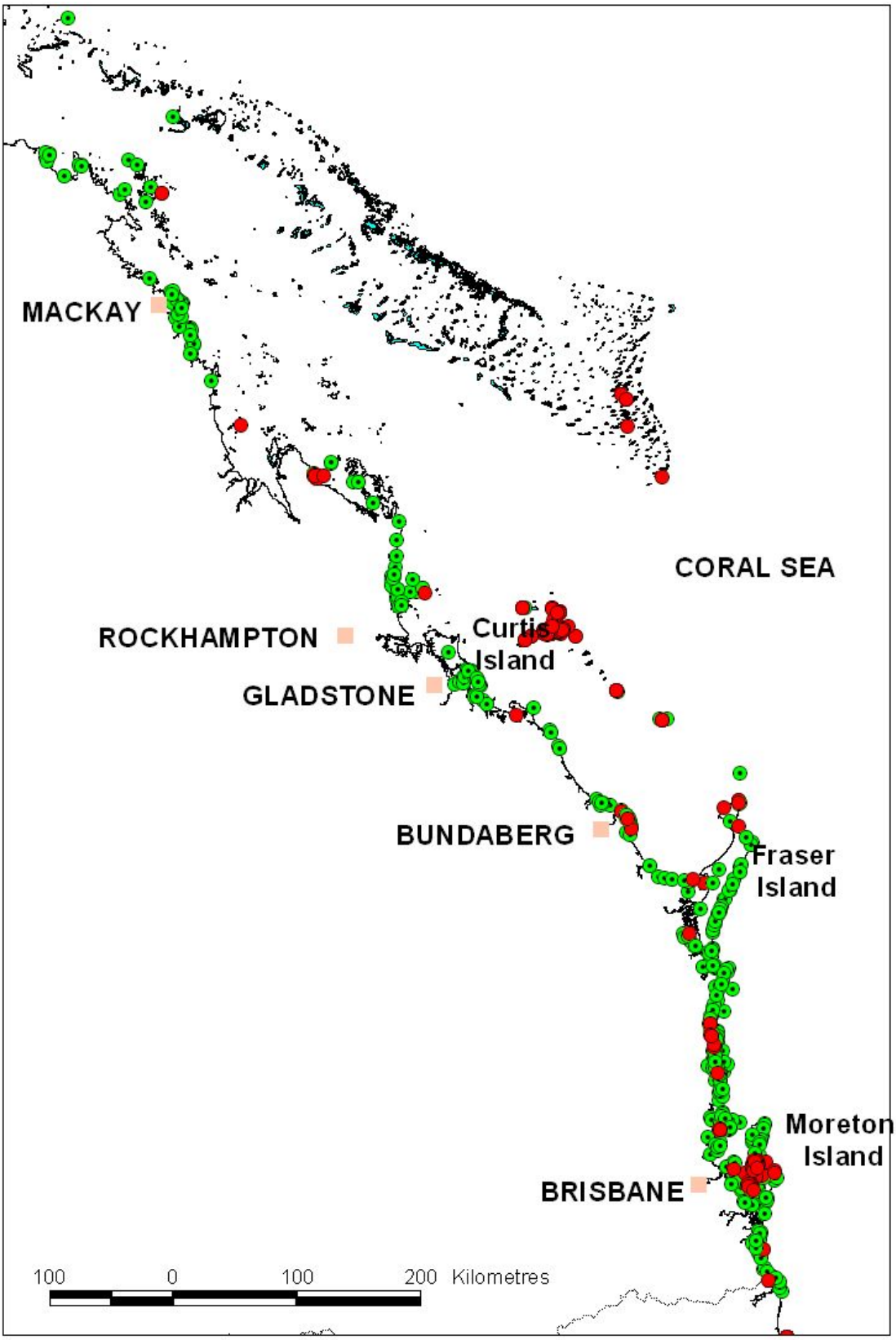


Figure 4. Records of non-nesting (presumed foraging) hawksbill turtles, *Lepidochelys olivacea* in south and central Queensland. Data derived from EHP Queensland Turtle Conservation data base and StrandNet. Red dots denote observations of live foraging turtles; green dots denote stranding records for moribund and dead hawksbill turtles

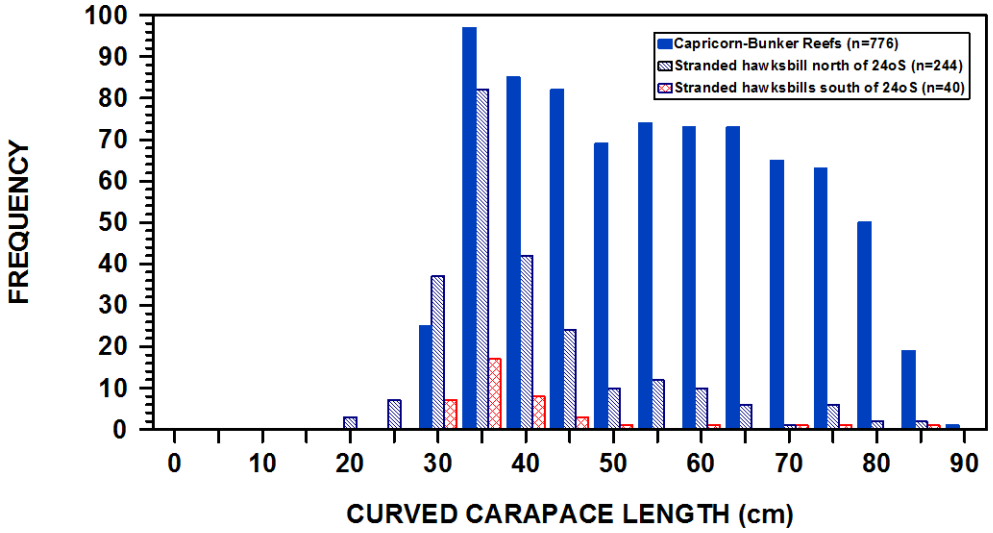


Figure 5. Size class distribution of Hawksbill turtles, *Eretmochelys imbricata,* from three sources:

- **Foraging turtles on Capricorn-Bunker reefs**
- **Stranded turtles from east Australia north of 24ºS within the Great Barrier Reef;**
- **Stranded turtles from east Australia south of latitude 24ºS;**

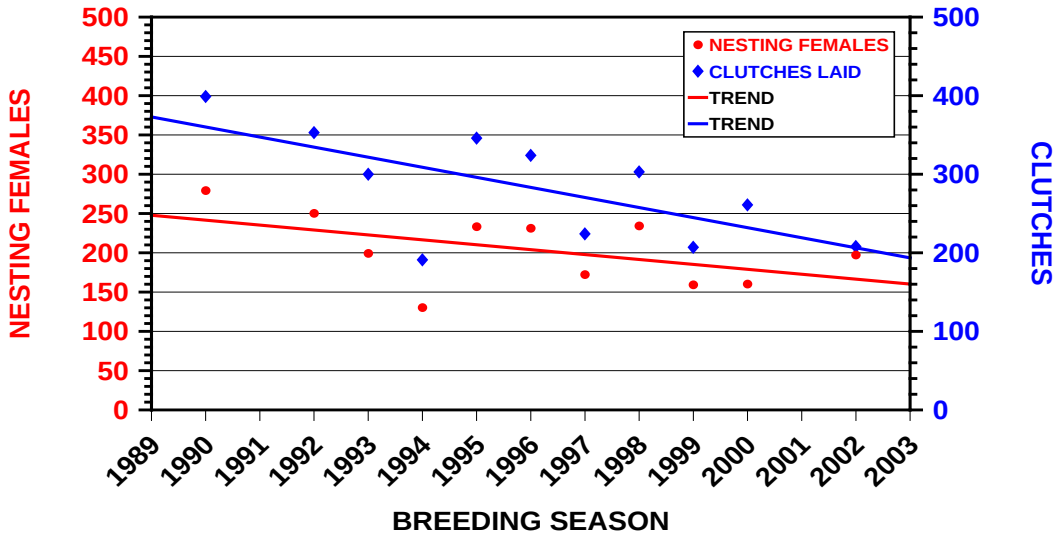


Figure 6. Milman Island hawksbill turtle index beach census: annual mid season, one month (15 January – 15 February) tagging census of nesting females and count of clutches laid. Based on data from Miller *et al*. (2008).