

QUEENSLAND TURTLE CONSERVATION PROJECT: DATA REPORT FOR MARINE TURTLE BREEDING ON THE WOONGARRA COAST, 2019-2020 BREEDING SEASON



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Cover photos, clockwise from the top left:

Local residents and visitors enjoying time with a satellite tagged turtle while she was laying eggs at Archies Beach.

Mon Repos Beach looking south from sector post 1.

Tour group with turtle at Mon Repos (Photograph by CTPI 49-Sch

QTC Volunteer relocating a clutch (Photograph by CTPI 49-Sch4

Loggerhead hatchlings crossing the beach

Light spill onto nesting beach at Bargara CBD (Photograph by CTPI 49-Sch4 Pendoley Environmental).

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The study was undertaken under Agreements between the Queensland Department of Environment and Science and Gladstone Ports Corporation to monitor marine turtle nesting and the Bundaberg Regional Council to monitor the response of the turtle nesting population to sky glow on the Woongarra Coast.

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EXECUTIVE SUMMARY

During the 2019-2020 turtle breeding season, 375 Loggerhead turtles, 10 Flatback turtles and 1 Green turtle were recorded ashore for breeding on the Woongarra Coast beaches.

Concern is expressed regarding trends in the Loggerhead nesting population:

- Reduction in the size of the annual nesting population over the past three summers.
- Continuing reduction in annual recruitment of young females into the breeding population.

Abnormal nesting behaviour that could be the result of excessive sky glow impact on the nesting turtles is of concern and warrants investigation:

- Unsatisfactory low nesting success was recorded for Loggerhead turtles at all Woongarra Coast beaches.
- All three species of turtles visiting Mon Repos Beach, a beach with no direct illumination, displayed a very high fidelity to visiting only that beach throughout the season. This contrasted with turtles that came ashore for nesting on beaches with direct illumination from coastal development at Oaks, Neilson Park, Kellys and Archies Beaches, which displayed very low fidelity to nesting at only a single nesting beach.

Although two turtles had a breeding lifespan exceeding 40 years, the population as a whole is still biased to relatively young adults. The majority of the nesting turtles commenced breeding after 2001, (the year that compulsory use of Turtle Exclusion Devices was regulated into the northern and eastern Australian prawn trawl fisheries) indicating that the population is still in a recovery mode following the impact of trawling bycatch mortality.

The impacts of continuing elevated summer temperatures on the Loggerhead breeding success on the Woongarra Coast are of concern:

- In response to the heatwave conditions of the 2019-2020 summer, turtles returned to lay their eggs at a shorter than usual re-nesting interval which resulted in turtles completing their multiple re-nesting cycles in a shorter time. This led to the breeding season ceasing approximately a month earlier than anticipated.
- As a consequence of heatwave conditions for the summer, the vast majority of Loggerhead clutches would have produced a strongly female biased hatchling sex ratio from all beaches of the Woongarra Coast (based on measured incubation periods to hatchling emergence for individual clutches and sand temperature measurements).
- Under the heatwave conditions of the 2019-2020 summer, the use of 25% shade cloth cover over the hatcheries and cages was not effective in managing the nest-depth sand temperatures necessary for producing hatchlings with an appreciable proportion of both sexes.
- Primarily as a result of our 4th consecutive excessively hot summer, unsatisfactory low Loggerhead hatching success and low hatchling emergence success was recorded at all beaches on the Woongarra Coast.
- As a consequence of repetitive heat wave conditions, Mon Repos Loggerhead breeding success has been seriously impacted by four consecutive years of greatly reduced hatchling emergence success.
 - o There is a very high probability that this is linked to a lowered water table under the dunes as a consequence of draining of the adjacent swampland. **Given the continuing probability of increased frequency of heat wave conditions this issue remains at an elevated level of concern.**

The mean size of the nesting females (95.4 cm), the mean number of clutches laid in a season (3.7), the mean number of eggs in a clutch (125.3) and the mean remigration interval (3.6 yr) recorded in 2019-2020 were similar to those recorded in recent years.

82.7% of Loggerhead turtle nesting attempts on the Woongarra Coast occurred on Mon Repos Beach.

Boat strike injuries to Loggerhead turtles while in their inter-nesting habitat were recorded on three nesting females that survived the propeller cuts and one adult female that died from the propeller cut injuries.

One nesting female was rescued from entrapment in Kellys Beach Lagoon following disorientation by street lights at the Causeway intersection.

For the 5th consecutive summer, no clutches of turtle eggs were lost to foxes at Mon Repos and for the first time in decades, no marine turtle eggs were destroyed by dogs, foxes, or goannas.

The relocation of 485 clutches of doomed Loggerhead eggs to more elevated incubation sites to minimise clutch loss to erosion, or to dark beaches to minimise the risk of hatchling disorientation towards coastal lighting, resulted in the rescue of 36.9% of the seasonal Loggerhead egg production on the Woongarra Coast.

With no cyclonic disturbance of beaches, only 13 Loggerhead clutches were recorded lost to flooding or erosion representing a 1% clutch loss for the summer.

As in past summers, nesting turtles digging into existing clutches of eggs caused only minor loss of eggs for the population.

QUEENSLAND TURTLE CONSERVATION PROJECT: DATA REPORT FOR MARINE TURTLE BREEDING ON THE WOONGARRA COAST, 2019-2020 BREEDING SEASON

1. INTRODUCTION

While four species of marine turtles have been recorded breeding on the Woongarra Coast, this coast is a primary index site for monitoring and researching the Loggerhead turtle, *Caretta caretta*, within the swPac genetic stock and a secondary index site for nesting Flatback turtles, *Natator depressus* within the eAust genetic stock (FitzSimmons and Limpus, 2014).

The Loggerhead turtle is listed as *endangered* under both Queensland and Commonwealth conservation legislations while the Flatback turtle is listed as *vulnerable*. International Union for the Conservation of Nature (IUCN) lists the Loggerhead turtle population of the South Pacific as critically endangered and the Flatback turtle as data deficient. As a consequence, Loggerhead turtles dominate the conservation considerations for marine turtles on the Woongarra Coast.

Loggerhead turtle breeding within the South Pacific Ocean forms an independent genetic stock that does not interbreed with other Loggerhead turtles elsewhere within the Pacific Ocean or Indian Ocean (FitzSimmons and Limpus, 2014. [Figure 1](#)). Loggerhead turtle breeding within the South Pacific Ocean is restricted to eastern Australia and New Caledonia, with the majority of the nesting occurring in eastern Australia.

There are five significant concentrations of Loggerhead turtle breeding in eastern Australia ([Figure 2](#); Limpus *et al.* 2013): Woongarra Coast and Wreck Rock Beaches on the mainland and Wreck, Tryon, and Erskine Islands within the Capricornia region of the southern Great Barrier Reef (GBR).

The Woongarra Coast in recent years has been supporting approximately 50% of annual Loggerhead turtle breeding in eastern Australia (Limpus *et al.* 2013).

The functioning of the Loggerhead turtle nesting in eastern Australia needs to be understood within the context of the complex life history that takes this population into diverse habitats throughout the South Pacific region and the associated diversity of threats to which it is exposed ([Figure 3](#)). While breeding success at the nesting beaches contributes to the functioning of the next generation that will return to breed in about 30 years' time, the next generation also has to survive as:

- Small post-hatchlings travelling along the East Australian Current (with exposure to ingestion of floating plastic debris) down the eastern Australian coast, past New Zealand at about six months old, and out into the wider South Pacific Ocean.
- Larger post hatchlings foraging in the plankton rich waters of the eastern Pacific Ocean off Chile and Peru (with exposure to fisheries bycatch in longline and gill net fisheries).
- Large post-hatchlings returning back across the South Pacific (still exposed to longline fisheries bycatch) to recruit into shallow coastal foraging areas of the Coral Sea – Tasman Sea region at about 16 years of age.
- Large immature and adult Loggerhead turtles foraging on benthic invertebrates in shallow coastal waters of the Gulf of Carpentaria, Coral Sea and Tasman Sea (exposed to crab fisheries bycatch, boat strike, decline in quality of coastal habitats in response to extreme weather events).

- Adults on their migrations of up to 2,600 km from their widely dispersed foraging areas to their traditional breeding sites.

In response to the diverse threats to the Loggerhead turtle, spanning multiple national jurisdictions across the entire South Pacific, the UNEP Convention for Conservation of Migratory Species (CMS) approved in 2014, the **Single Species Action Plan for the Loggerhead Turtle (*Caretta caretta*) in the South Pacific Ocean** (UNEP/CMS/Resolution 11.21; UNEP/CMS/COP11/Doc 23.2.2/Rev.1/Annex 2) (CMS, 2014). As a signatory state to CMS, the Australian Government is expected to implement this Action Plan. This report summarises part of the Queensland Government's contribution to implementation of the Single Species Action Plan for the Loggerhead Turtle in the South Pacific Ocean.

2. METHODS

The Woongarra Coast supports nine small crescent sand beaches in an otherwise 22 km of rocky coast line between the Burnett and Elliott Rivers in northern Hervey Bay, south Queensland ([Figure 4](#)). The inter-tidal areas of these beaches and the majority of the adjacent sub-tidal waters are within the Great Sandy Marine Park. The longest of these beaches is Mon Repos beach (1.6 km) where the nesting habitat occurs mostly within the Mon Repos Conservation Park that is managed by the Queensland Department of Environment and Science (DES). The remaining beaches are principally within esplanades managed by the Bundaberg Regional Council, except for Kellys Beach where the nesting habitat extends into the seaward margin of privately owned properties.

Standard methodologies of the DES Queensland Turtle Conservation Project (QTCP) within the Aquatic Threatened Species Program (Limpus *et al.* 1983; Limpus, 1985) were followed for this project, monitoring nesting females and their clutches. Statistical procedures follow Zar (1984). Proportional data were presented as the value $\pm$ 95% confidence interval.

Monitoring teams included DES staff and QTCP volunteers with prior training with the methodologies being implemented. DES is indebted to the tireless efforts of our large team of local volunteers who patrolled the beaches, tagged the turtles, relocated doomed eggs, and recorded data at the Bargara, Burnett Heads and Elliott Heads beaches.

Data management

DES maintains the QTCP database which collates data on marine turtle tagging and sightings from nesting beaches, foraging grounds, and stranded turtles. The data are coded into a relational database to facilitate statistical analysis. The data are routinely analysed to investigate:

- distribution and abundance of nesting by beaches
- trends in size of nesting populations and other demographic parameters
- description of population characteristics by study year

To support maintenance of a sustainable turtle population the regional goal is to manage for in excess of 70% of clutches laid surviving to produce hatchlings (Commonwealth of Australia, 2017). Hatching success of eggs in excess of 80% is expected when there is no external interference with the eggs and environment conditions of the nest remain within the normal range for marine turtle eggs (NRC 1990). This high hatching success was characteristic of the loggerhead hatching success of undisturbed clutches at Mon Repos Beach during the first decade of monitoring of this population (Limpus *et al.* 2013).

Nesting activity

Nesting activity was recorded at all nesting beaches along the Woongarra Coast during the entire breeding season from late October 2019 to March 2020. Monitoring of nesting occurred nightly and additionally during the cooler hours of the day for assessing incubation through late January to May. Procedures included:

- Flipper tagging following the standard methods reported by Limpus (1992). Adult turtles left the beach with a minimum of two titanium tags manufactured by Stockbrands Australia in the front left and right flippers, generally proximal to the flipper scute closest to the body. If scar tissue from previous tagging made this position unsuitable, tags were applied distally to this scute or on hind flippers.
- Flipper tagging using monel tags with this nesting population commenced in 1968 but these tags only lasted a few years before they were lost to corrosion. The introduction of double tagging with titanium tags in 1981 has enabled long term recognition of the individual nesting turtles (Limpus, 1992). Past studies have established that since 1982, any turtle nesting on the Woongarra Coast that is untagged and does not have tag scars from lost previously applied tags, has a 98% probability of being a first time breeding turtle. This has enabled the assigning a year for commencement of breeding to these first time tagged females with a high level of confidence.
- Passive Integrated Transponder (PIT) tags manufactured by Animal Electronic I.D. Systems were injected into the upper left (or occasionally right) shoulder (just below the carapace) of nesting Flatback and Green turtles and a limited number of high priority Loggerhead turtles.
- Curved carapace length (CCL $\pm$ 0.1 cm) was measured from the skin/carapace junction at the anterior edge of the nuchal scale, along the midline, to the posterior junction of the two post-vertebral scutes at the rear of the carapace, using a flexible fibreglass tape measure. Any *Chelonibia* barnacles living along the midline of the carapace were removed prior to measuring.
- Any damage to the turtle or unusual features were recorded and photographed if possible.
- A nest tag (flagging tape ~20 cm long) with the date of laying and a tag number of the turtle (Limpus, 1985) was placed in the nest during oviposition for most clutches. The nest tag enabled identification of individual clutches of eggs when excavated following hatchling emergence some two months later.
- A subset of clutches was counted, and ten eggs were selected to represent a cross-section of eggs from top to bottom of the nest. Each selected egg was weighed ($\pm$ 0.1 g) on a digital balance and measured for maximum and minimum diameter ($\pm$ 0.1 mm) with vernier callipers. To minimise movement induced mortality of eggs, all handled eggs were returned to their respective nests within two hours of being laid and with the minimum of rotation (Limpus *et al.* 1979).
- When clutches were counted, nest depths from the beach surface to the top of the eggs and to the bottom of the nest were measured with fibreglass flexible tape measures ($\pm$ 1 cm).
- Nest locations were recorded by triangulation measurements from pairs of numbered posts along the crest of the upper dune and extending for the full length of Mon Repos, Oaks, and Archies Beaches.
 - o No surface markers were placed on individual nests

Rescuing of doomed eggs

Since the late 1980s, it has been standard management for the majority of clutches of eggs that are laid below or close to the high tide level on the Woongarra Coast to be relocated to more secure incubation sites higher up the dunes. This relocation was completed within 2 hours of the eggs being laid and with the minimum of rotation of the eggs (Limpus *et al.* 1979; Pfaller *et al.* 2008). While the majority of the relocation of clutches was managed by DES staff and trained volunteers, some clutches were relocated to safer incubation sites on Mon Repos with the assistance of supervised tourist visitors as part of the Department's environmental education of the broader community ([Figure 5](#)).

Because of the high risk of hatchlings heading inland from Neilson Park, Bargara and Kellys Beaches, the majority of clutches of eggs laid on these beaches were relocated to a darker beach, either Mon Repos or Archies Beaches, on the night that they were laid or approximately three weeks later.

Incubation cages and hatcheries

In response to the heat wave weather conditions that commenced in December, several hundred clutches were relocated into standard shaded, predator-proof cages ([Figure 6A](#)) at Mon Repos, Archies and Elliott Heads Beaches or into shaded, open-sided hatcheries ([Figure 6B](#)) at Mon Repos Beach. To provide relocated clutches with a cooler incubation environment at Mon Repos and Archies Beaches, the cages and hatcheries were covered by shade cloth that reduce sunlight penetration by 25%. The predator-proof cages were enclosed with aluminium mesh with 70 mm diameter mesh size allowing self-release of hatchlings emerging from the enclosed nests.

During the 2019-2020 summer predator-proof cages were installed at Elliott Heads ([Figure 6C](#)) and at Moore Park with the assistance of the Bundaberg Regional Council and Gidarjil Land and Sea Rangers to provide increased protection of eggs from potential fox and dog depredations.

Location of predator proof incubation cages and hatcheries on the Woongarra Coast, 2019-2020 breeding season:

Mon Repos Beach:

- Cage 1: sector 1, top of 2nd dune, shaded by *Casuarina* from approximately midday onward
- Cage 2: Sector 8, 1st dune, shaded by *Casuarina* from approximately 2pm onward
- Cage 3: Sector 10, 1st dune, not shaded by the forest until after approximately 5pm
- Cage 4: Sector 14B, 2nd dune, shaded by *casuarina* after approximately 12:30pm
- Hatchery 1: Sector 9C, 1st dune, receives shade from the forest after approximately 4:30pm
- Hatchery 2: Sector 13C, 1st dune, receives shade from *Casuarina* after 3:30 pm

Archies Beach:

- Cage 7: Sector 8, 1st dune, shaded by *Casuarina* from approximately 3pm onward

Elliott Heads:

- Cage 8: 1st dune, shaded by *Casuarina* from approximately 3pm onward

Incubation and emergence success

Nests were excavated for assessing incubation success and hatchling emergence success after hatchlings had emerged. Previously recorded nests were located using measurements from marker posts and confirmed by the presence of nest tags. Nests were excavated no sooner than 24 hours after hatchling emergence or at 9 weeks if hatchlings had not emerged. Procedures included:

- If hatchling emergence was observed and when logistically feasible, a sample of 10 hatchlings (+ any live-in-nest) were weighed (± 0.1 g), measured (± 0.1 mm) with vernier callipers and the scale pattern counted and photographed.
- Observations of heat stress were noted that included:
 - dead hatchlings that had emerged but died in the vicinity of the nest, with no signs of predation.
 - dead hatchlings in the neck of the nest that were not otherwise trapped by roots from emerging.
 - elevated numbers of dead pipped eggs.
- The number of hatched eggs was determined by counting the number of eggshell fragments that were larger than 50% of that expected from an entire egg.
- Clutches were assessed for any signs of predation by crabs or other animals and counts were made of any hatched live or dead hatchlings within the nest.
- Unhatched eggs were opened to determine whether the embryo had developed to an observable stage or whether it appeared to be undeveloped.
- Estimated clutch count = hatched eggs + unhatched eggs + undeveloped eggs + depredated eggs.
- Hatchling incubation success was calculated as: (hatched eggs/estimated clutch count) x 100%.
- Emergence success was calculated as: (hatched eggs – [live + dead hatchlings] /estimated clutch count) x 100%.
- Counting error, the accuracy of counting broken egg shells, was calculated as: estimated clutch count following hatchling emergence minus clutch count made when the eggs were laid. This metric was used to direct training with team members making counts with elevated errors.
- The depth to the bottom of the egg chamber was measured (± 5 mm) and observations on the nest environment were made with respect to erosion and water inundation.

Hatchling sex ratio theory

The sex of marine turtle hatchlings is determined by the temperature of the nest presumably during the middle third of incubation (Reed, 1980; Yntema and Mrosovsky, 1980, 1982). The pivotal temperature, (the theoretical temperature that will result in equal proportions of male and female hatchlings) for the SW Pacific Loggerhead turtle population is 28.6°C (Limpus *et al.* 1985), with higher temperatures producing predominantly females and lower temperatures producing predominantly males. If Loggerhead eggs incubate at a constant temperature of 28.6°C:

- Hatching should occur approximately 58 days after the eggs were laid.
- Allowing for 2-3 days for the hatchlings to dig to the beach surface for emergence, the incubation period from laying to hatchling emergence should be approximately 60-61 days.

Thus, incubation duration can be informative regarding the sex of hatchlings. However, heavy rainfall will also influence the sex ratio (Reed, 1980) as cool rain results in a decline in sand temperatures with a corresponding potential to produce more male hatchlings. In contrast, sand temperatures increase in the short term in the absence of rain and as a result of reduced evaporative cooling within the sand. The warmer sand temperatures can be expected to result in an elevated production of female hatchlings.

Extreme weather

The Australian Bureau of Meteorology has identified that 2019 was the hottest year on record for Australia ([Figure 7](#)). 2019 was also the 6th hottest year on record for Queensland. Daily minimum and maximum air temperatures and rainfall were accessed via the Australian Bureau of Meteorology from Bundaberg Aero {station 039128} for the year, 1 July 2019 to 30 June 2020 ([Figure 8](#)). By early December 2019, Mon Repos was exposed to the 4th consecutive heat wave summer in coastal south Queensland.

There were no tropical cyclones in the Coral Sea region that impacted negatively on beach stability on the Woongarra Coast during the 2019-2020 summer turtle breeding season.

Environmental Monitoring

Vemco Minilog II temperature data loggers have been deployed for a number of years at turtle nesting beaches in Queensland to measure sand temperatures at 50 cm depth at 30 minute intervals. These temperature recording instruments can record temperature continuously for up to 10 years. Temperature data loggers continued to be deployed on Mon Repos Beach year round within the turtle nesting habitat at the standard temperature monitoring locations:

- Sector 14, on 1st dune grassy habitat in open sun but exposed to afternoon shade from the forest inland of the turtle nesting habitat.
- Sector 9C, on the crest of the 2nd dune in open sun and only exposed to shade from the adjacent forest in the late afternoon.

Additional temperature data loggers were deployed similarly within the centre of each of the four shaded predator-proof incubation cages on Mon Repos Beach and at the front wall and at the rear wall of the predator-proof cage at Archies Beach.

These sand temperature measurements provide an index of sand temperature at approximately nest depth for Loggerhead and Flatback turtles in the absence of metabolic heating. Metabolic heating of the incubating eggs commences to increase during the temperature sensitive incubation phase when sex of the embryo is determined (Reed, 1980; Yntema and Mrosovsky, 1982).

Graphical summaries of the sand temperatures at 50 cm depth are presented for the temperature data loggers at Mon Repos sector 14 ([Figure 9A](#)), sector 9C ([Figure 9B](#)) and centre of each of the shaded predator-proof cages: cage 1 ([Figure 10A](#)), cage 2 ([Figure 10B](#)), cage 3 ([Figure 10C](#)) and cage 4 ([Figure 10D](#)). Similar summaries are presented for sand temperature data from the shaded predator-proof cage at Archies Beach: front ([Figure 10E](#)) and back ([Figure 10F](#)).

Surface sand temperature was measured using an infrared thermometer ($\pm 1^{\circ}\text{C}$).

3. RESULTS

Marine turtle nesting populations on the Woongarra Coast, 2019-2020.

Turtle nesting on the Woongarra Coast commenced with the first nesting on 16 October 2019 and the last nesting on 21 February 2020 ([Table 1](#)).

The marine turtle hatchling emergence from nests on the Woongarra Coast commenced on 7 December 2019 and ceased on 22 April 2020 ([Table 1](#)).

Based on the whole of nesting season capture-mark-recapture nightly tagging of all turtles encountered, a total of 386 individual marine turtles of three species were recorded ashore for nesting on the Woongarra Coast beaches during the 2019-2020 breeding season ([Table 2](#)).

3.1. LOGGERHEAD TURTLES, *Caretta caretta*

Breeding population size

A total of 375 Loggerhead turtles were recorded ashore for breeding on the Woongarra Coast beaches this summer. The long term trends in the annual nesting census data ([Figure 11](#)) from the 1970s to 2000, illustrates the major decline in annual numbers of nesting Loggerhead turtles attributed primarily to otter trawl by-catch mortality. The compulsory use of Turtle Exclusion Devices (TEDs) has been regulated via Australian and Queensland fisheries regulation across northern Australia, Torres Strait and eastern Queensland since 2001 (Limpus, 2008). As a consequence, recent Loggerhead turtle nesting numbers on the Woongarra Coast have recovered to a size that is comparable to those of the early 1980s. However, there has been an unexplained decline in the size of the annual Loggerhead turtle nesting population on the Woongarra Coast over the last three breeding seasons.

The annual recruitment rate of Loggerhead turtles (= proportion of turtles recorded for breeding for the first time on the Woongarra Coast) was 0.24 ± 0.04 for the 2019-2020 breeding season. This index of recruitment into the adult female breeding population has declined by approximately 50% over the last two decades ([Figure 12](#)). Because this loggerhead population is characterised with age at first breeding at approximately 30yr, this current decline in recruitment will be, in part, a consequence of the declining nesting population three decades ago. Additional impacts that will contribute to this decline in recruitment will include fisheries bycatch mortality in the southeast Pacific Ocean and post-hatchling mortality from ingestion of microplastic debris while travelling in the East Australian Current. This continuing decline in recruitment of new adults into the breeding population is of concern.

The 2019 marine turtle breeding season on the Woongarra Coast ([Table 1](#)) commenced at the expected time, based on commencement date recorded in recent decades. However, in contrast with past cooler summers, the 2019-2020 breeding season ceased approximately a month earlier than expected. This was the result of warmer temperatures and the speeding up of the physiological processes for preparing clutches of eggs while the turtles were in the inter-nesting habitat off-shore from the Woongarra Coast. In addition, the peak density of nesting activity which normally can be expected to commence in mid-December and continue into the first few days of January was shortened and ceased before the end of December 2019 ([Figure 13](#)).

Reproductive parameters

The size range of the nesting Loggerhead turtles are summarised in [Table 4](#) and [Figure 14A](#). The mean CCL of 95.4 cm is typical of the eastern Australian Loggerhead nesting population. Nesting females tended to increase in carapace length with increasing reproductive age ([Table 4](#)).

The nesting Loggerhead turtles averaged 3.7 clutches laid per female for the summer ([Table 3](#); [Figure 14B](#)). Nesting females tended to increase the number of clutches laid per season with increasing reproductive age ([Table 5](#)).

The nesting Loggerhead turtles averaged 125.3 eggs per clutch ([Table 3](#); [Figure 14C](#)). The occurrence of yolkless and multi-yolked eggs in clutches was uncommon ([Table 3](#)). Nesting females tended to increase the number of eggs per clutch with increasing reproductive age ([Table 6](#)).

When a Loggerhead turtle successfully completed the laying of a clutch she remained offshore in the inter-nesting habitat while preparing her next clutch for laying and returned to the shore to nest again after an average of 12.5 days ([Table 3](#); [Figure 14D](#)). This unusually short re-nesting interval is most likely due to the unusually warm summer. When a nesting Loggerhead turtle came ashore for laying and was disturbed before she laid any eggs, she returned to the sea and came back to shore for another attempt to lay the same clutch after an average of 0.9 days ([Table 3](#); [Figure 14E](#)).

The nesting Loggerhead turtles averaged approximately 3.6 yr between seasons ([Table 3](#); [Figure 14F](#)). Nesting females tended to decrease the number of years between breeding seasons with increasing reproductive age ([Table 7](#)).

Changes in mean values of CCL, number of clutches laid per female per season, number of eggs in a clutch and remigration interval between the 2019-2020 breeding season and the previous season were not statistically significant.

Nesting behaviour

The proportion of marine turtle nesting crawls and nesting success by Woongarra Coast beaches during the 2019-2020 breeding season are summarised in [Table 8](#).

The vast majority ($82.8 \pm 1.4\%$) of the Loggerhead turtle nesting attempts occurred on Mon Repos Beach and the remaining 21.2% of the nesting crawls were spread over the remaining seven beaches ([Table 8A](#)). Mon Repos has been the primary beach supporting Loggerhead turtle nesting on the Woongarra Coast in all years since systematic monitoring of turtle nesting began in 1968 ([Figure 15](#)).

Unsatisfactory, low nesting success was recorded for Loggerhead turtles across all Woongarra Coast beaches for the 2019-2020 season ([Table 8A](#)). It is of concern that numerous turtles turned around when only partway up the beach and returned to the sea without laying eggs in the absence of observed physical disturbance (e.g. absence of people or dogs; absence of obstructions such as erosion banks or beach debris). The role of sky glow over the nesting beach as a disturbance factor impacting marine turtle breeding success warrants investigation.

Turtles that came ashore to nest on the Woongarra Coast displayed an acceptable level of fidelity to an individual nesting beach for all three species with 71.5% of Loggerhead turtles and 100% of both Flatback and Green turtles respectively visiting only a single beach throughout the entire nesting season ([Table 9A](#)). All three species of turtles visiting Mon

Repos Beach displayed a very high fidelity to visiting only that beach throughout the season ([Table 9B](#)). In contrast, turtles that came ashore for nesting at Oaks, Neilson Park, Kellys and Archies Beaches displayed very low fidelity to nesting at only a single nesting beach.

Turtles that bred on the Woongarra Coast with the longest recorded reproductive life spans were:

- Loggerhead turtle, **X-8440**: 42 yr reproductive life span, commenced breeding in the 1977-1978 breeding season, with 15 recorded breeding seasons.
- Flatback turtle, **X23103**: 45 yr reproductive life span, commenced breeding in the 1974-1975 breeding season, with 17 recorded breeding seasons.

Following the decimation of the eastern Australian Loggerhead turtle nesting population, recovery of the annual nesting numbers commenced following the compulsory regulation of the use of TEDs in the prawn trawl fisheries of northern Australia, Torres Strait, and eastern Queensland in 2001. As a consequence, 303 (90.7%) of the Loggerhead turtles with a known reproductive life span commenced their breeding life since 2001 ([Figure 16A](#)). The excessive Loggerhead turtle mortality across decades throughout the majority of the foraging distribution prior to 2001 is interpreted as the underlying reason for there being only 9.2% of older turtles (>19 yr reproductive life) still migrating to this major breeding site.

There was a marked decline in the proportion of turtles returning to breed after more than three breeding seasons ([Figure 16B](#)). There was no tight correlation between the reproductive life span of the adult female Loggerhead turtle and the number of recorded breeding seasons ([Figure 16C](#)). It is presumed that the variability in reproductive life span/number of recorded breeding seasons will be influenced by environmental factors operating across the multiple foraging areas supporting these turtles prior to their breeding migrations. There was a strong bias for turtles with a long reproductive life span to commence breeding early in the breeding season and for turtles that arrived late in the breeding season to be breeding for the first time ([Figure 16D](#)).

In response to the high summer temperatures and the resulting shortening of the re-nesting interval, the turtles completed the laying of their multiple clutches in a shorter period than normal during the 2019-2019 breeding season. As a consequence, although the nesting activity reached a peak abundance in about mid-December as expected, nesting activity declined below peak abundance about a week earlier than expected in late December ([Figure 13](#)).

Boat strike injuries in the inter-nesting habitat

Three of the season's nesting Loggerhead turtles survived boat strike injuries that occurred while they were in the adjacent inter-nesting habitat while preparing another clutch of eggs for laying:

- **K42677**, 27 December 2019: adult in her 6th breeding season, CCL = 99.5 cm; recorded with fresh propeller cuts to the carapace that had occurred between laying her 2nd and 3rd clutches for the season.
- **QA21571**, 2 January 2020: adult in her 4th breeding season, CCL = 93.8 cm; recorded with fresh propeller cuts to the carapace that had occurred between laying her 1st and 2nd clutches for the season.
- **QA55945**, 27 January 2020: adult in her 2nd breeding season, CCL = 103.6 cm; recorded with fresh propeller cuts to the carapace that had occurred between laying her 4th and 5th (final) clutches for the season.

One adult female Loggerhead turtle that had been nesting at Moore Park during the 2019-2020 breeding season washed ashore dead from propeller cuts:

- **QA55860**, 11 December 2019: adult female, CCL = 96.0 cm; nesting at Moore Park
 - o 23 December 2019: beach-washed with fresh propeller cuts to the carapace before laying her 2nd last clutch for the season. Necropsy results ([Figure 17](#)):
 - adult female that had bred in past seasons; had laid at least 2 clutches already for the season
 - a full clutch of shelled eggs in the oviducts and sufficient mature follicles in the ovaries for another clutch of eggs

Rescued turtle

One nesting Loggerhead turtle was rescued from entrapment in Kellys Beach lagoon following disorientation by street lights at the Causeway intersection:

- **QA86532, 9 February 2020**: Adult female in her 1st breeding season; CCL = 96.7 cm; after successfully laying a clutch of eggs on the open dune at the southern end of Kellys Beach at 7:30 pm. She headed inland towards the street lights at the Causeway intersection. Volunteers using bright torches led her from the water's edge of the lagoon back to the sea. Her eggs were relocated to the darker Archies Beach. **21 February 2020**: She changed beaches to lay her final clutch for the season at Mon Repos.

Loss of clutches and eggs

For the 5th consecutive summer there were no clutches of turtle eggs lost to foxes at Mon Repos. This is attributed to the successful fox den fumigation and associated soft-jaw trapping project conducted by QPWS on the Woongarra Coast. There were occasional records of fox tracks on Mon Repos Beach throughout the summer and a limited number of sightings of foxes at night in the immediate vicinity of the Conservation Park. It is presumed that this fox control program has reduced the number of foxes in the district with prior experience of predation on turtle eggs. Collectively for all beaches on the Woongarra Coast, no marine turtle eggs were destroyed by either dogs or foxes. The new predator-proof cage at Elliott Heads contributed to this result.

Only 13 clutches of Loggerhead turtle eggs were recorded as lost to erosion during spring tides associated with higher wind velocities ([Table 10](#)). This is equivalent to the loss of $1.0 \pm 0.5\%$ of the season's egg production.

A total of 485 clutches of doomed Loggerhead eggs were relocated to more elevated incubation sites to minimise clutch loss to erosion and flooding, or to dark beaches to minimise the risk of hatchlings disoriented towards coastal lighting. These relocated clutches are equivalent to rescuing $36.9 \pm 2.5\%$ of the seasonal Loggerhead egg production on the Woongarra Coast for the 2019-2020 breeding season.

Thirty-five incubating Loggerhead clutches were dug into during subsequent nesting activities of Loggerhead turtles ([Table 10](#)). In each case only part of the incubating clutch was destroyed by the nesting turtle. As in past seasons, egg destruction by nesting turtles represented the loss of only a small proportion of the total season's Loggerhead egg production on the Woongarra Coast.

Incubation success and hatchling emergence

Of the 1314 recorded Loggerhead clutches laid on the Woongarra Coast during the 2019-2020 breeding season, 1223 clutches were accounted for following hatchling emergence.

There were 91 (6.9%) clutches that were not accounted for at hatchling emergence. Some clutches remained as “not located” at hatchling emergence because of faulty triangulation measurements when the eggs were laid.

[Figure 18](#) summarises the frequency distribution of incubation period from laying until hatchlings emerged onto the beach surface (PTE) for Loggerhead clutches laid on all beaches of the Woongarra Coast.

[Figure 19](#) summarises the PTE for Loggerhead clutches laid by individual beaches of the Woongarra Coast during 2019-2020 breeding season.

[Table 11](#) summarises the PTE for Loggerhead clutches laid on the Woongarra Coast beaches by species and relocation history of the eggs.

In the absence of directly quantified hatchling sex ratio from sacrificing hatchlings for histological gonad examination, the sex of hatchlings for the season is approximated via two data sources:

1. Sand temperatures at nest depth measured with temperature data loggers. Female biased hatchling sex ratio occurs when nest temperatures during mid-incubation period are above the pivotal temperature (= 28.6°C for Loggerhead turtles). Nest temperatures at mid incubation within a clutch of eggs can be expected to be slightly above sand temperatures in the absence of eggs because of metabolic heating that commences in about mid incubation.
2. PTE, period of incubation from laying to hatchling emergence from the nest. Female biased hatchling sex ratio occurs when PTE is shorter than the pivotal PTE (= 60-61 days for Loggerhead turtles), in the absence of a cooling spike in sand temperatures induced by heavy rain.

Sand temperature records at nest depth ([Figure 10](#)) from all monitoring sites (Mon Repos: open beach monitoring sites at sectors 14A and 9C and four shaded predator-proof cages. Archies Beach: one shaded predator-proof cage) show a consistent pattern of sand temperatures:

- Temperatures were above the Loggerhead pivotal temperature throughout approximately the entire breeding season.
- Except during three brief periods of heavy rain-induced cooling that gave temperatures below the pivotal temperature causing masculinising of clutches laid approximately 1 month before the dates:
 - o 1 January 2020
 - o 18-20 January 2020
 - o 5-6 February 2020

These sand temperature data indicate that the Loggerhead hatchling sex ratio from the Woongarra Coast beaches will have been strongly female biased during the 2019-2020 breeding season.

As a consequence of the general heatwave conditions for the summer ([Figure 9](#), [Figure 10](#)), the vast majority of the clutches on all beaches of the Woongarra Coast had a PTE much shorter than 60 days. As a result of temperature dependant sex determination considerations, this PTE result potentially translates to a strongly female biased sex ratio for hatchlings produced from the Woongarra Coast for this summer ([Figure 18](#), [Figure 19](#); [Table 11](#)). An exact sex ratio cannot be predicted from PTE alone because the three brief cooling spikes in sand temperatures caused by three brief periods of intense rainfall will have masculinised those clutches at mid-incubation at those times without necessarily substantially lengthening the PTE (Reed, 1980; Yntema and Mrosovsky, 1982).

Under the heatwave conditions of the 2019-2020 summer, the use of 25% shade cloth cover over the hatcheries and cages was not effective in managing sand temperatures at nest depth necessary for producing hatchlings with an appreciable proportion of both sexes ([Figure 19A-F](#); [Table 11](#)).

[Table 12](#) summarises the hatching success of eggs and hatchling emergence success from nests on the Woongarra Coast by beaches and relocation history of the clutches. Overall, there was less than desirable Loggerhead hatching success and hatchling emergence success on all beaches and in all of the hatcheries and cages except for cage 4. The reduced hatchling productivity resulted from a combination of multiple negative impacts on the incubating eggs and emerging hatchlings:

- At least 300 clutches were severely impacted by the heatwave conditions with elevated mortality of over-heated hatchlings attempting to dig to the beach surface or increased numbers of debilitated hatchlings in the dry sand above the hatched eggs. This resulted from excessively hot-dry surface conditions such that dry sand collapsed into the egg chamber at pipping of the eggs, preventing hatchlings from aggregating into the normal well defined neck of the egg chamber. Surface sand temperatures in excess of 70°C in open sun were recorded on multiple days during this summer.
- At least 354 clutches were severely impacted by the heatwave conditions as determined by multiple dead hatchlings on the beach surface adjacent to the nest, multiple dead hatchlings below the beach surface but above the egg shell or elevated numbers of dead pipped and/or full term embryos. Collectively this negative impact reduced hatchling production within at least $26.9 \pm 2.7\%$ of the Loggerhead clutches for the season with a hatching success = 61.8% and hatchling emergence success = 49.7% for these clutches.
- At least 93 ($7.1 \pm 1.4\%$) Loggerhead clutches were negatively impacted by root invasion during incubation of the eggs with resulting death of eggs and some entrapment of hatchlings.

The collective reduction in hatchling production from all identified sources (heatwave, root invasion of nests, erosion, high tide flooding of nests, turtles digging into existing clutches) represents in excess of 35% of clutches with greatly reduced hatchling production at the most important Loggerhead nesting area in eastern Australia.

It has been previously identified that hatchling emergence success from clutches laid on Mon Repos Beach have been reduced and fluctuate more widely from year to year since the swampland immediately inland of the dunes was drained by the local farming company, with associated lowering of the water table beneath the frontal dune. Decreases in hatchling emergence success occur in hot or low rainfall years. The Loggerhead hatchling emergence success from natural nests laid in the more elevated areas of the frontal dune at Mon Repos in 2019-2020 was the 4th lowest hatchling emergence success recorded in the half century of monitoring this index of breeding success ([Figure 20](#)). Mon Repos Loggerhead breeding success has been seriously impacted by four consecutive years of greatly reduced hatchling emergence success ([Figure 20](#)) associated with hot dry sand conditions on the frontal dunes. There is a very high probability that this is linked to a lowered water table under the dunes as a consequence of draining of the adjacent swampland. Given the continuing probability of increased frequency of heat wave conditions data ([Figure 7](#)), this issue remains at an elevated level of concern.

3.2. FLATBACK TURTLES, *Natator depressus*

A total of 10 Flatback turtles were recorded ashore for breeding on the Woongarra Coast beaches this summer ([Table 2](#)). The small annual Flatback turtle nesting population on the Woongarra Coast continues to fluctuate but remains within the range recorded over the last half century ([Figure 21](#)).

All Flatback turtle nesting for the Woongarra Coast for the 2019-2020 season occurred at Mon Repos. In contrast with Loggerhead turtles, the Flatback turtles displayed excellent nesting success (83%; [Table 8B](#)).

No incubating Flatback clutches were dug into during subsequent nesting activities by Loggerhead turtles ([Table 10](#)).

[Table 13](#) summarises the reproductive parameters of this small nesting population at the southern extremity of the breeding range for eAust genetic stock of Flatback turtles for the 2019-2020 breeding season. The reproductive parameters recorded for this season continue to fall within the normal range for these parameters for this stock (Limpus, 2007).

Flatback clutches on the Woongarra Coast during the 2019-2020 breeding season had a mean PTE = 49.5 d ([Table 11](#)). The spread of PTE during the season ([Figure 22](#)) indicates that the Flatback hatchling sex ratio also should have been strongly female biased. Some of the clutches laid in the early season would have produced a male bias while clutches laid in the mid to late season should have produced predominantly female hatchlings ([Figure 22](#)).

The Flatback clutches had an unsatisfactory hatching success (mean = 70.1%) and hatchling emergence success (mean = 68.4%) ([Table 12](#)), attributable to the heatwave and root invasion of nests that occurred on Mon Repos Beach this summer.

3.3. GREEN TURTLES, *Chelonia mydas*

Only one Green turtle was recorded nesting on the Woongarra Coast during the 2019-2020 breeding season: QA60071, adult female in her 1st recorded breeding season; CCL = 97.1 cm; laid 7 clutches of eggs for the season on Mon Repos Beach. All nesting crawls by this turtle occurred at Mon Repos with a low nesting success (44%; [Table 8C](#)). Based on PTE and sand temperature records for the season, the Green turtle hatchling sex ratio would have been extremely female biased from this minor Green turtle breeding site ([Figure 9](#), [10](#), [22](#)). This turtle had high incubation success and hatchling emergence success from her clutches ([Table 12](#)).

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FIGURES

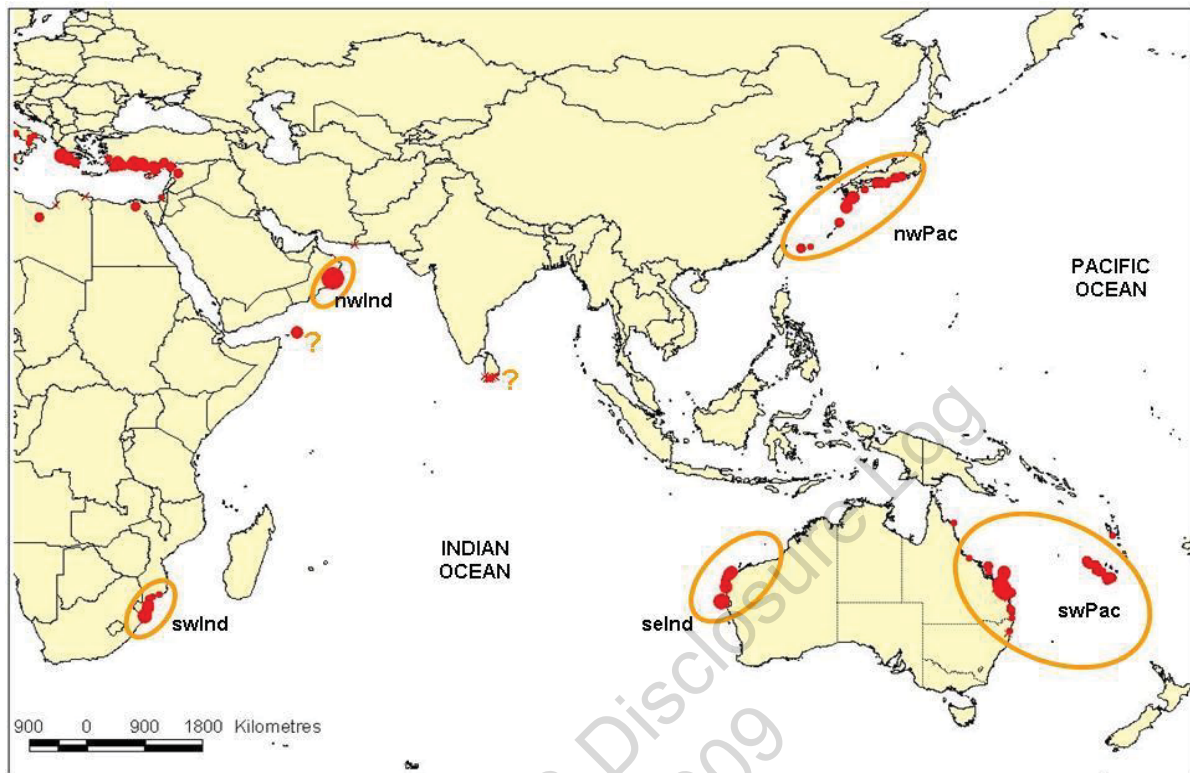


Figure 1: Genetic stocks (management units) of Loggerhead turtles, *Caretta caretta*, within the Pacific and Indian Oceans (FitzSimmons and Limpus, 2014).



Figure 2: Nesting distribution of Loggerhead turtles, *Caretta caretta*, in eastern Australia with the five principal nesting sites identified.

LOGGERHEAD TURTLE, *Caretta caretta*
TRANS PACIFIC MIGRATION IN SOUTH PACIFIC OCEAN

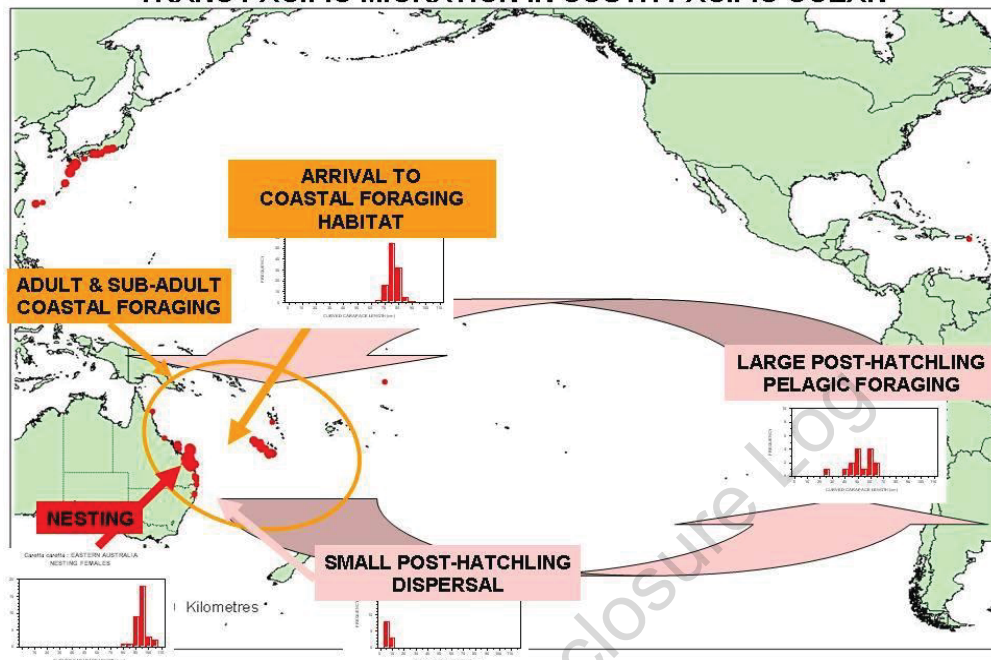


Figure 3: Summary of the life history dispersal of the SW Pacific genetic stock of Loggerhead turtles (CMS, 2014).



Figure 4: Map of the locations of the marine turtle nesting beaches on the Woongarra Coast.



Figure 5: Tourist visitor assisted with relocation of eggs to a safer incubation site under supervision of DES QPWS staff at Mon Repos Beach.



6A. Hatchery cage (C1), sector 1, dune crest, Mon Repos Beach.



6B. Open hatchery (H1), north Beach, sector 9c, Mon Repos Beach.



6C. Hatchery cage (C8), dune crest, Elliott Heads

Figure 6: Shaded incubation structures on Mon Repos Beach and Elliott Heads, Woongarra Coast.

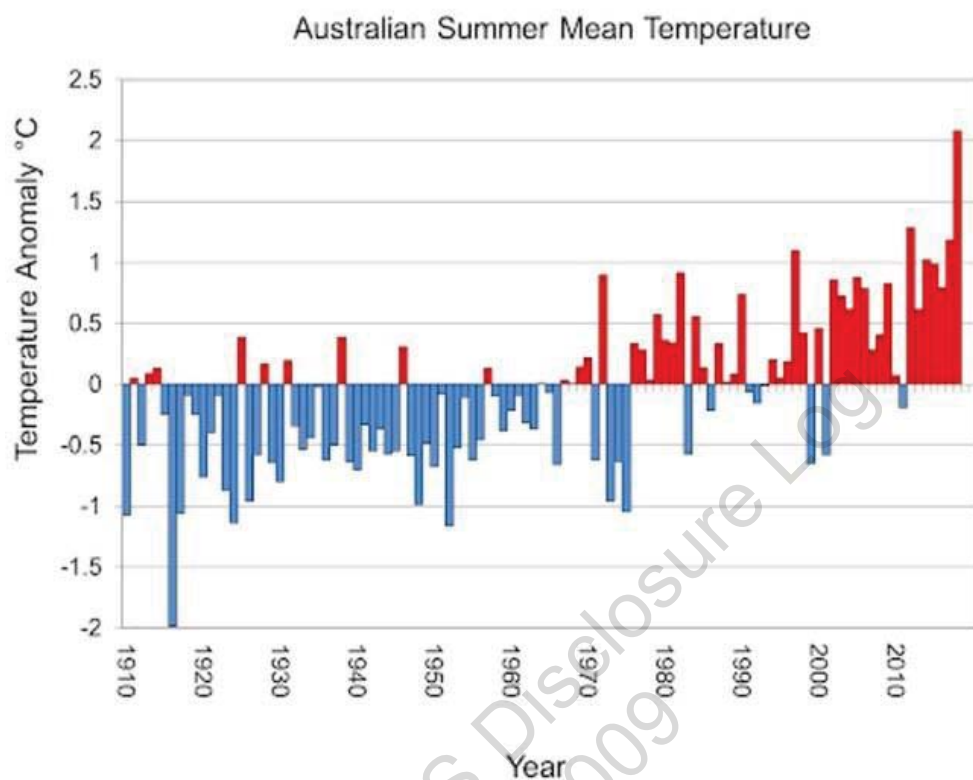


Figure 7: Australian summer mean temperature anomalies derived from the 1981-1990 average temperatures (Australian Bureau of Meteorology, sourced 4 July 2020).

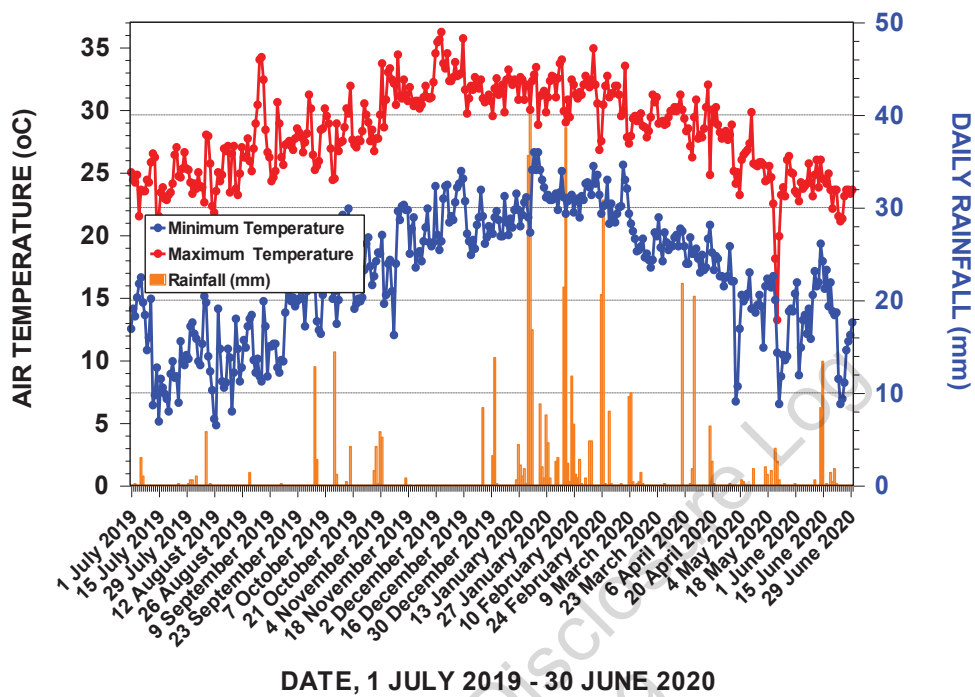
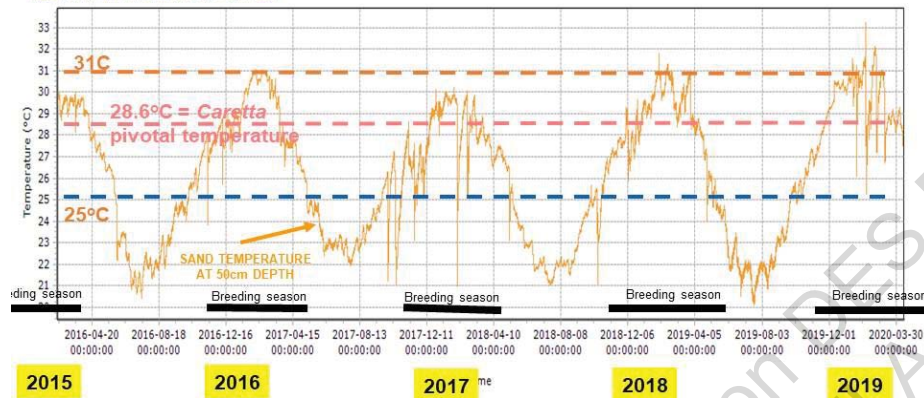


Figure 8: Daily minimum and maximum air temperatures and rainfall recorded at Bundaberg Aero (Station 039128) by the Australian Bureau of Meteorology (sourced 04 July 2020).

**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Feb 2016– Mar 2020
SECTOR 14, DUNE GRASS**

Source File: Minilog-II-T_356325_20200414_1.vld
Source Device: Minilog-II-T-356325
Study Description: MR 14_dune-sun replacement
Minilog Initialized: 2016-02-17 18:27:09 (UTC+10)
Study Start Time: 2016-02-18 00:00:01
Study Stop Time: 2020-04-14 08:00:01
Sample Interval: 00:30:00
Temperature (°C) Mean: 26.25 Min: 20.09 Max: 33.25

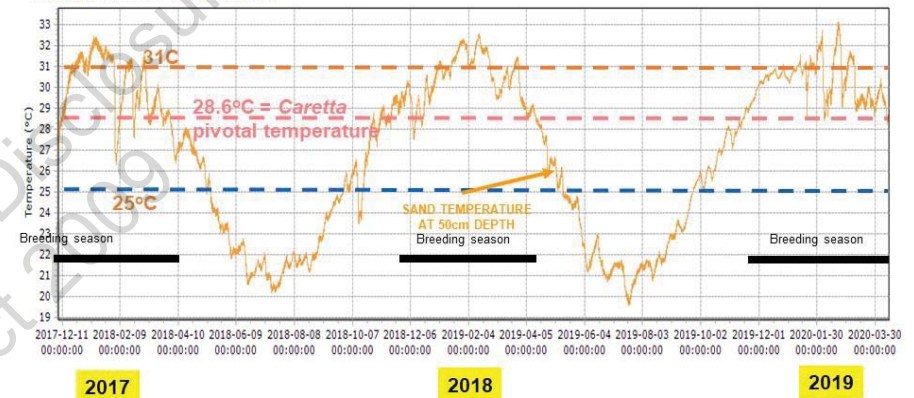
**BEST INCUBATION
RANGE = 25-31°C**



**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2017– Mar 2019
SECTOR 9C, DUNE GRASS**

Source File: Minilog-II-T_358257_20200414_1.vld
Source Device: Minilog-II-T-358257
Study Description: MR17_9C_open sun dune
Minilog Initialized: 2017-12-06 16:19:14 (UTC+10)
Study Start Time: 2017-12-07 00:00:00
Study Stop Time: 2020-04-14 06:30:00
Sample Interval: 00:30:00
Temperature (°C) Mean: 27.06 Min: 19.60 Max: 33.14

**BEST INCUBATION
RANGE = 25-31°C**



9A. Sector 14 in open sun, receiving forest shade in the late afternoon.

9B. Sector 9C in open sun, receiving forest shade in the late afternoon.

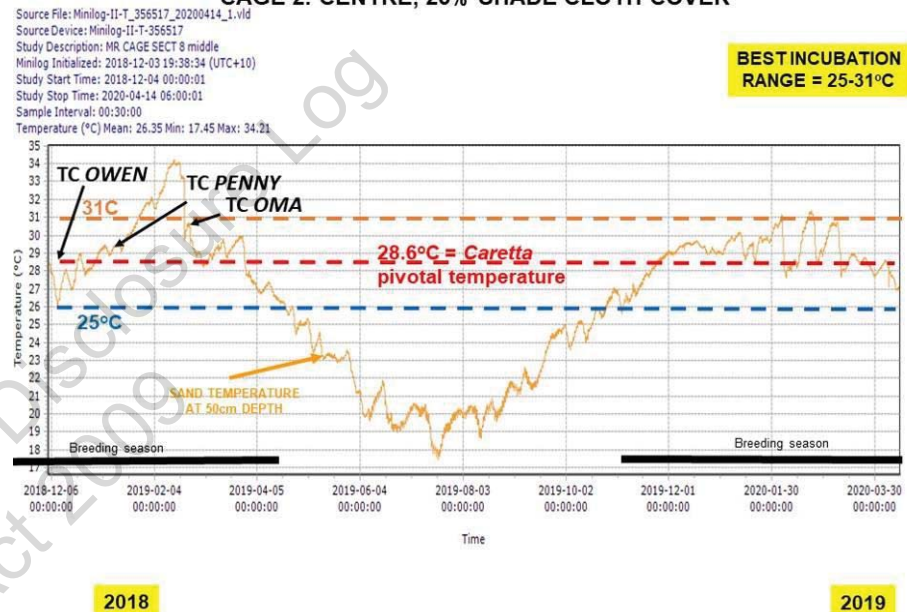
Figure 9: Plot of daily sand temperature data at the two standard recording sites on Mon Repos Beach.

**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018-Dec 2019
CAGE 1, CENTRE, 25% SHADE CLOTH COVER**



10A. Shaded predator-proof Cage 1, on the 2nd dune, sector 1, Mon Repos Beach (Figure 6A). The data logger malfunctioned at downloading of data in March 2020.

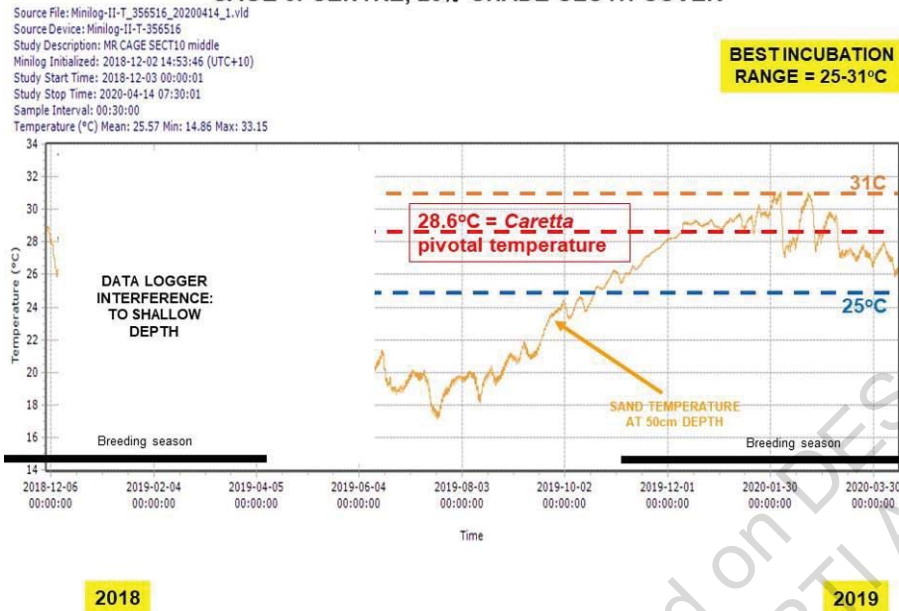
**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018–Mar 2020
CAGE 2: CENTRE, 25% SHADE CLOTH COVER**



10B. Shaded predator-proof Cage 2, on the 1st dune, sector 8, Mon Repos Beach (Figure 6B).

Figure 10: Plot of daily sand temperature data within shaded (25% shade cloth) predator-proof incubation cages, Woongarra Coast.

**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018–Mar 2020
CAGE 3: CENTRE, 25% SHADE CLOTH COVER**



10C. Shaded predator-proof Cage 3, on the 1st dune, sector 10, Mon Repos Beach. The data logger was disturbed during the 2018-2019 summer and recorded at an incorrect depth for several months.

Figure 10. Continued.

**MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018–Mar 2020
CAGE 4: CENTRE, 25% SHADE CLOTH COVER**



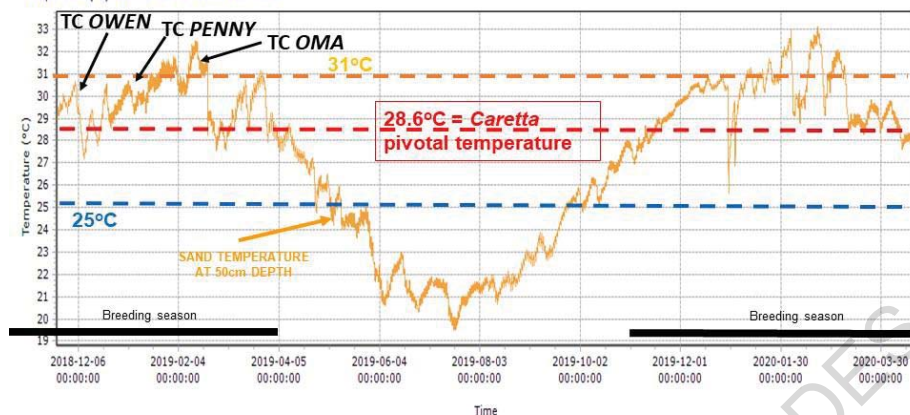
10D. Shaded predator-proof Cage 4, on the 2nd dune, sector 14B, Mon Repos Beach.

MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018–Mar 2020

CAGE 7, FRONT: 25% SHADE CLOTH COVER

Source File: Minilog-II-T_356513_20200420_1.vld
Source Device: Minilog-II-T-356513
Study Description: Archies Bch_cage 7_front_sunny
Minilog Initialized: 2018-11-22 05:49:41 (UTC+10)
Study Start Time: 2018-11-23 00:00:01
Study Stop Time: 2020-04-20 10:30:01
Sample Interval: 00:30:00
Temperature (°C) Mean: 27.32 Min: 19.49 Max: 33.12

BEST INCUBATION
RANGE = 25-31°C



2018

2019

10E. Shaded predator-proof Cage 7 (front), on the dune, Archies Beach.

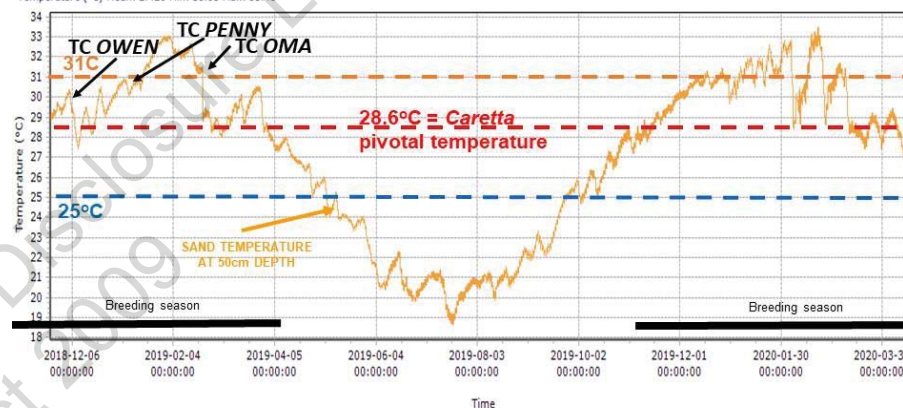
Figure 10. Continued.

MON REPOS SAND TEMPERATURES AT 50cm DEPTH :Dec 2018–Mar 2020

CAGE 7, BACK: 25% SHADE CLOTH COVER

Source File: Minilog-II-T_356514_20200420_1.vld
Source Device: Minilog-II-T-356514
Study Description: Archies Bch_cage 7_back_sunny
Minilog Initialized: 2018-11-22 05:51:31 (UTC+10)
Study Start Time: 2018-11-23 00:00:01
Study Stop Time: 2020-04-20 10:42:40
Sample Interval: 00:30:00
Temperature (°C) Mean: 27.26 Min: 18.65 Max: 33.48

BEST INCUBATION
RANGE = 25-31°C



2018

2019

10F. Shaded predator-proof Cage 7 (rear), on the dune, Archies Beach.

***Caretta caretta* : WOONGARRA COAST**
TOTAL ANNUAL NESTING POPULATION (TAGGING CENSUS)

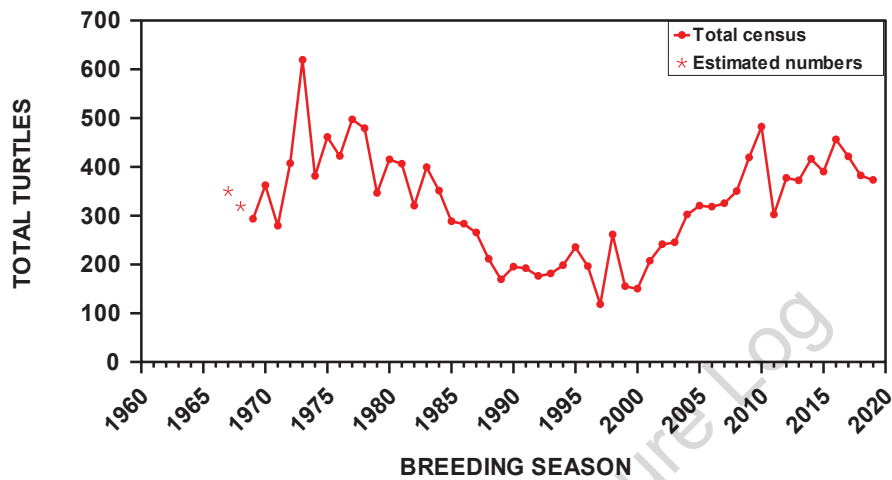
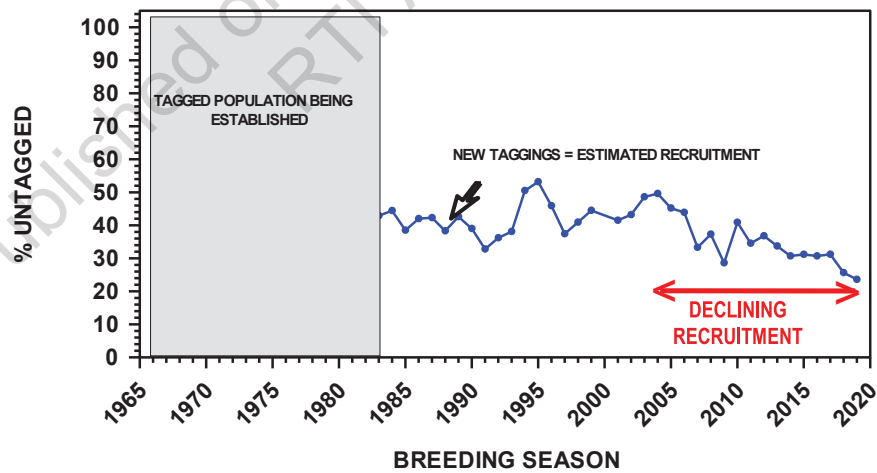


Figure 11: Summary of changing breeding numbers of Loggerhead turtles, *Caretta caretta*, on the Woongarra Coast, 1968-2019.



THIS PROVIDES AN ESTIMATE OF RECRUITMENT OF FIRST TIME BREEDERS TO THE POPULATION

Figure 12: Proportion of first time tagged adult female Loggerhead turtles, *Caretta caretta*, within the annual breeding population on the Woongarra Coast, based on capture-mark-recapture analysis.

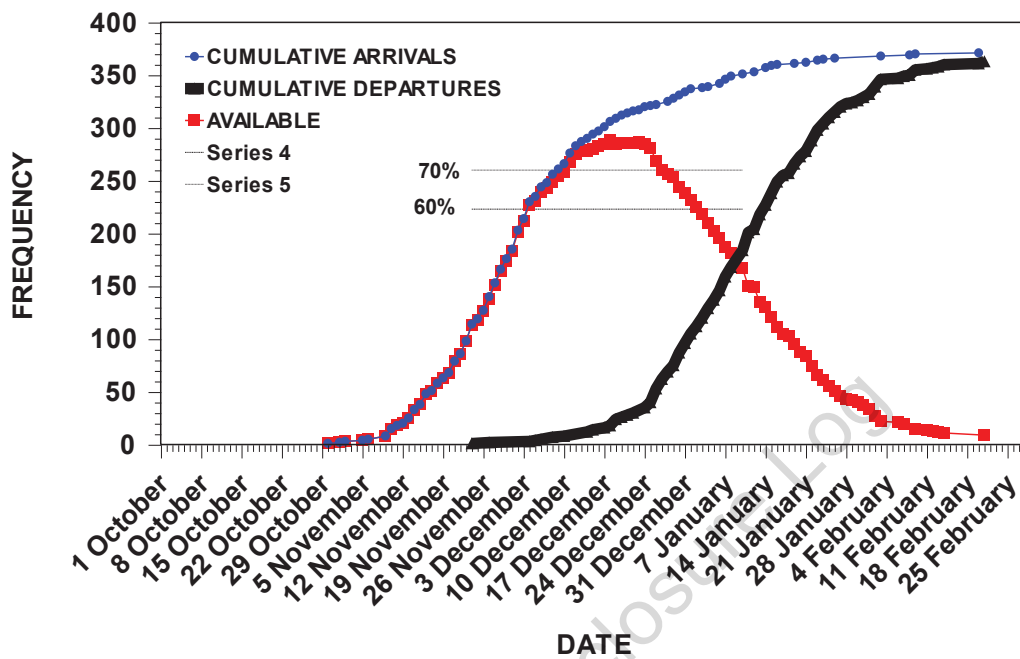
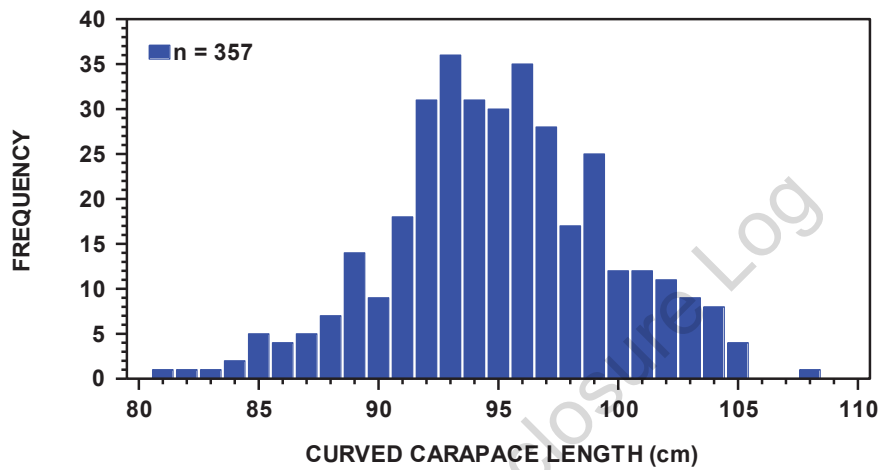
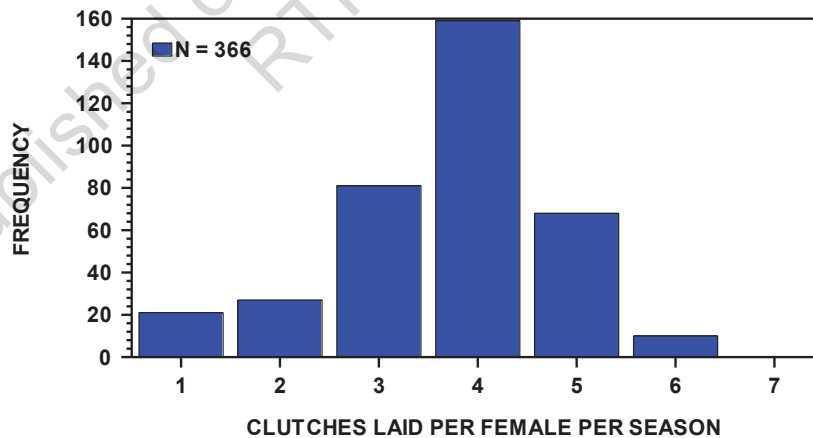


Figure 13: Availability of Loggerhead turtles, *Caretta caretta*, on the Woongarra Coast during the 2019-2020 breeding season. Availability is quantified as the difference between the cumulative numbers of turtles that have commenced nesting (arrivals) and of turtles that had laid their last clutch for the season (departures).

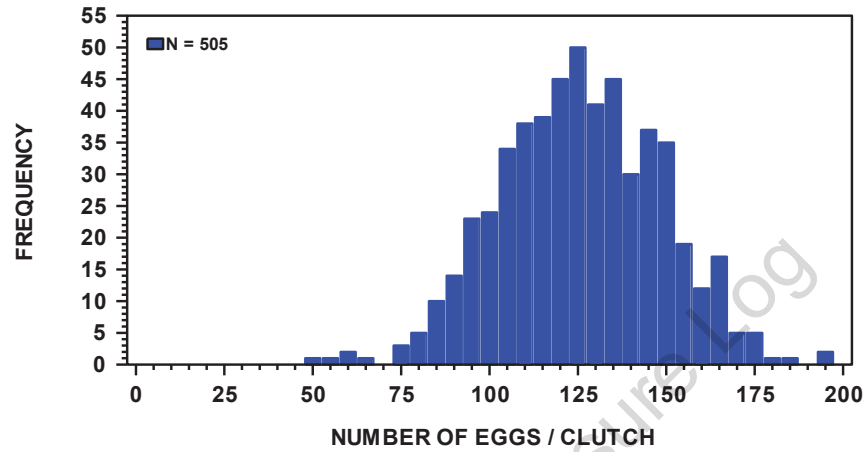


14A. Curved carapace length for the total annual nesting population.

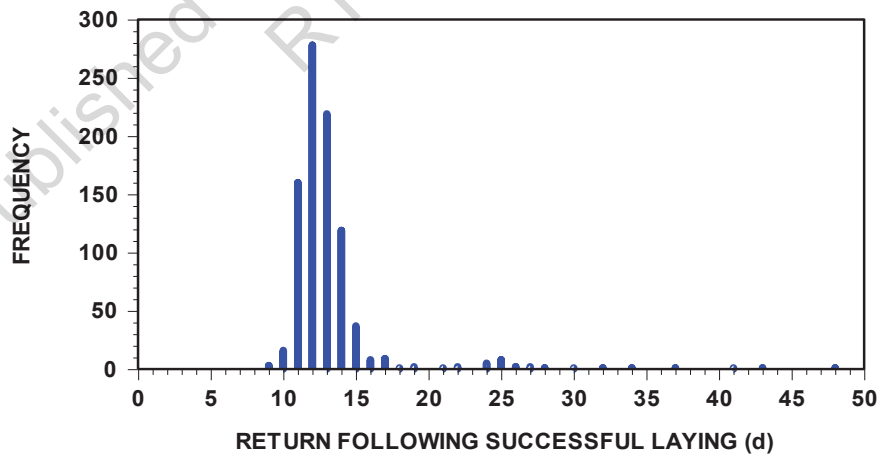


14B. Number of clutches of eggs laid recorded for each female within the breeding season.

Figure 14: Reproductive parameters for Loggerhead turtles, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season.

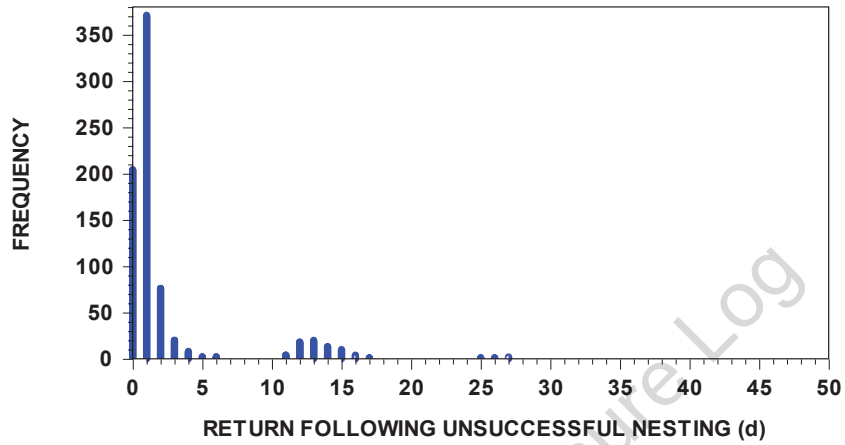


14C. Number of eggs per clutch.

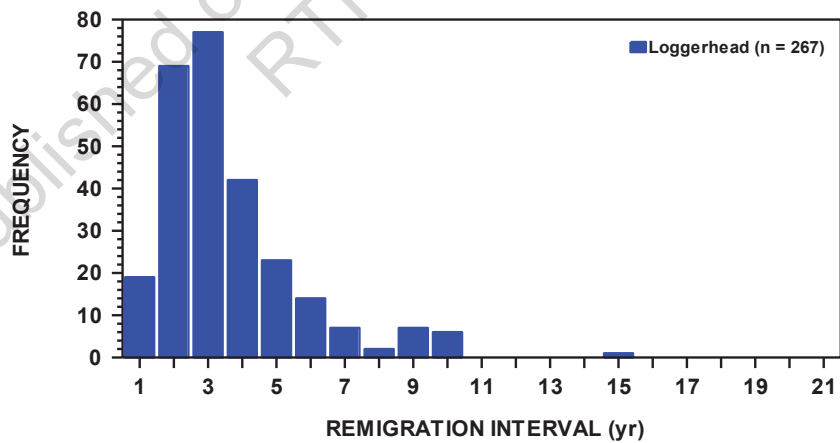


14D. Re-nesting interval following a successful nesting.

Figure 14. Continued



14E. Re-nesting interval following an unsuccessful nesting attempt.



14F. Remigration interval (years between successive breeding seasons).

Figure 14. Continued

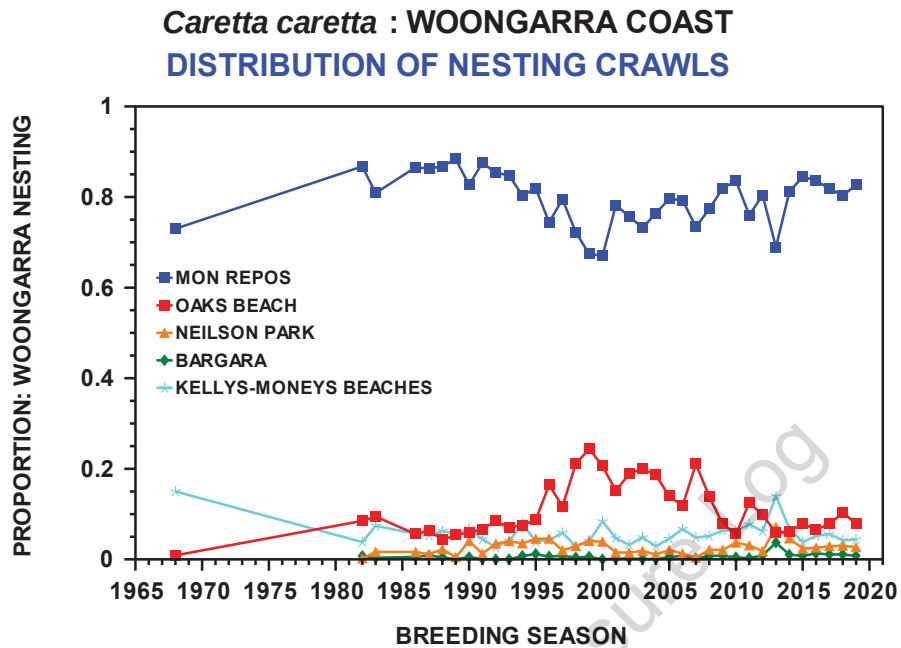
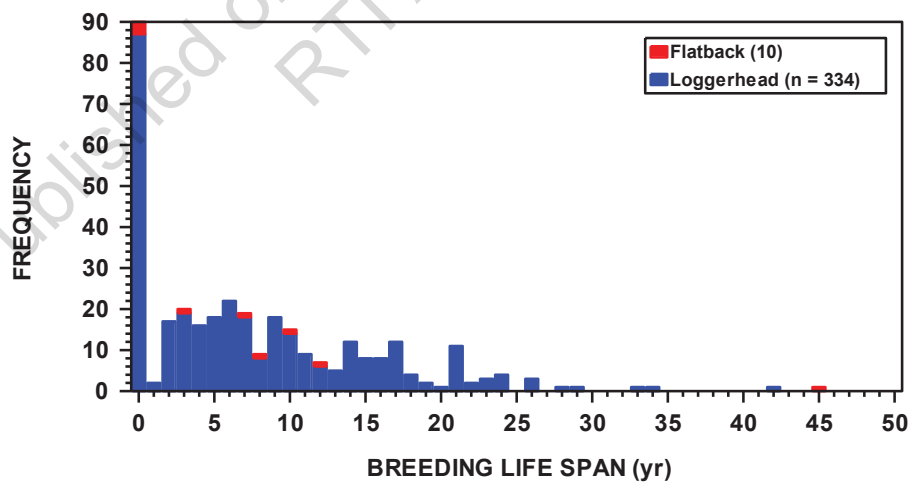
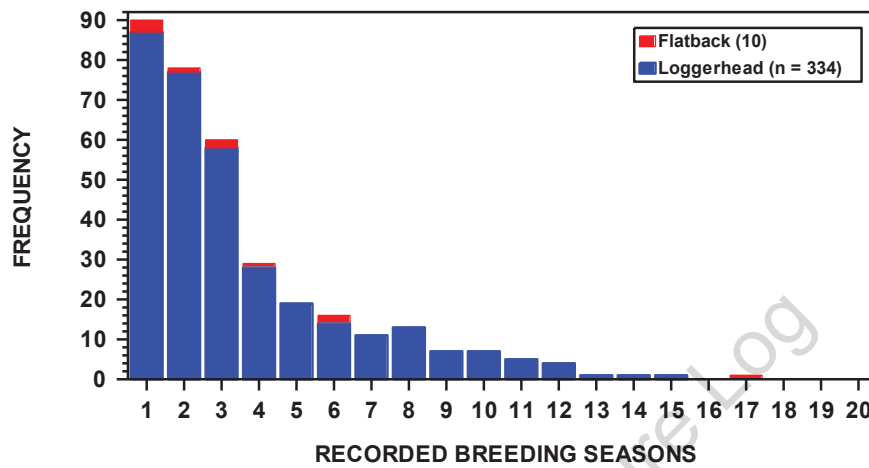


Figure 15: Distribution of Loggerhead turtle, *Caretta caretta*, nesting crawls by principal nesting beaches within the Woongarra Coast, 1968-2019 breeding seasons.

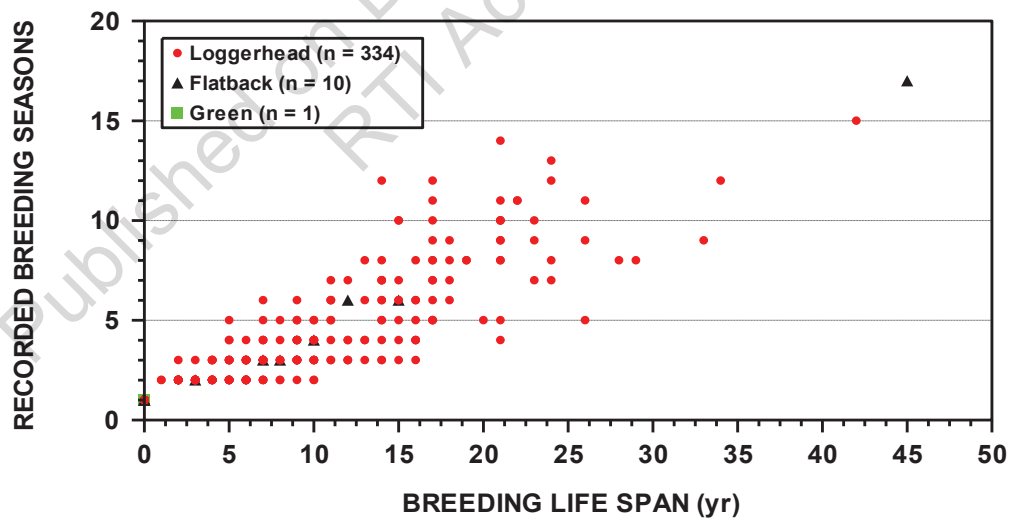


16A. Reproductive life span.

Figure 16: Breeding history of Loggerhead turtles, *Caretta caretta*, and Flatback turtles, *Natator depressus*, with known commencement of reproductive life, that nested on the Woongarra Coast during the 2019-2020 breeding season.

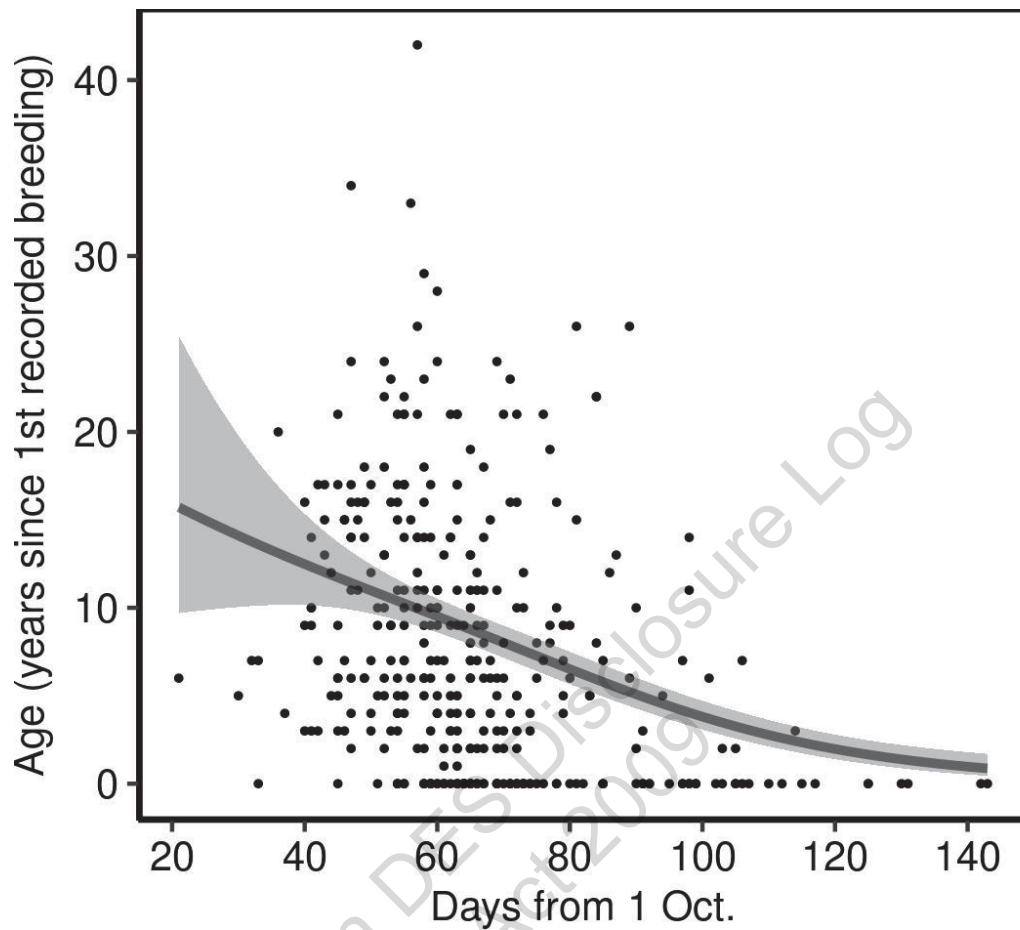


16B. Number of breeding seasons per turtle.



16C. Number of breeding seasons by reproductive life span.

Figure 16. Continued.



16D. Date of arrival for commencement of nesting of Loggerhead turtles of known breeding age on the Woongarra Coast (GAM model with a gamma distribution using a log link).

Figure 16. Continued.



17A. Fresh propeller cuts to rear carapace.



17B. Counting and measuring oviducal eggs

Figure 17: QA55860, 23 December 2019: adult female Loggerhead killed by boat strike in the inter-nesting habitat off the Woongarra Coast while preparing for returning to nest on Moore Park Beach.

WOONGARRA COAST 2019-2020 BREEDING SEASON
***Caretta caretta* : INCUBATION PERIOD TO EMERGENCE (d)**

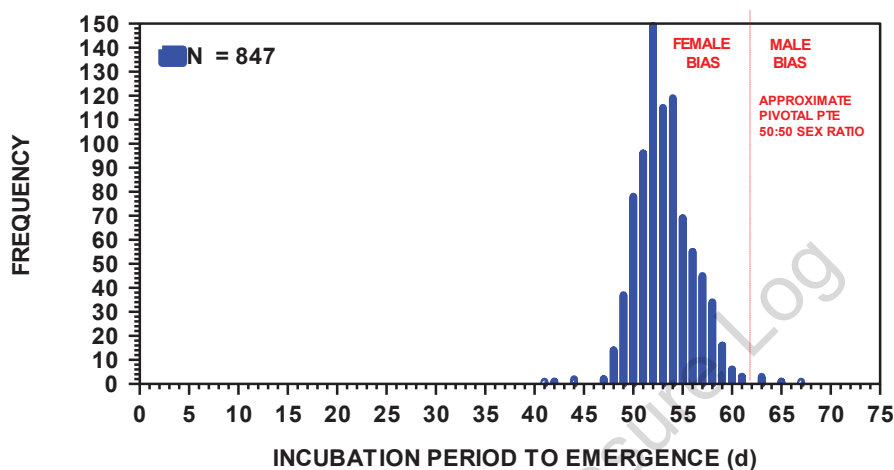
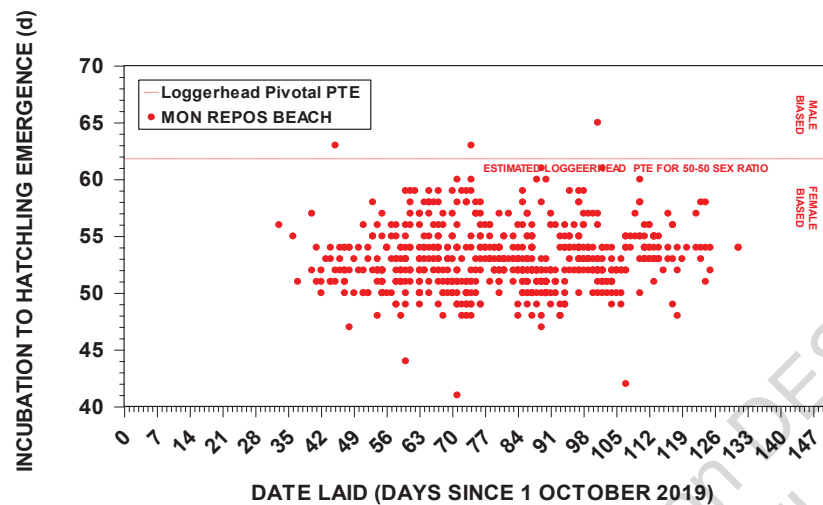
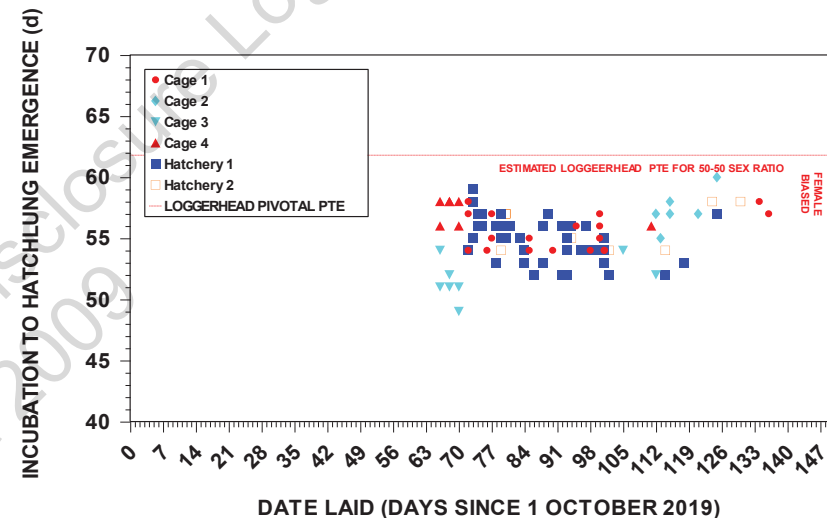


Figure 18: Frequency distribution of incubation period from laying of eggs to hatchlings emerging to the beach surface (PTE) for Loggerhead turtle, *Caretta caretta*, eggs laid on the Woongarra Coast during the 2019-2020 breeding season. The pivotal period from laying to hatchling emergence is estimated from Limpus *et al.* (1985).

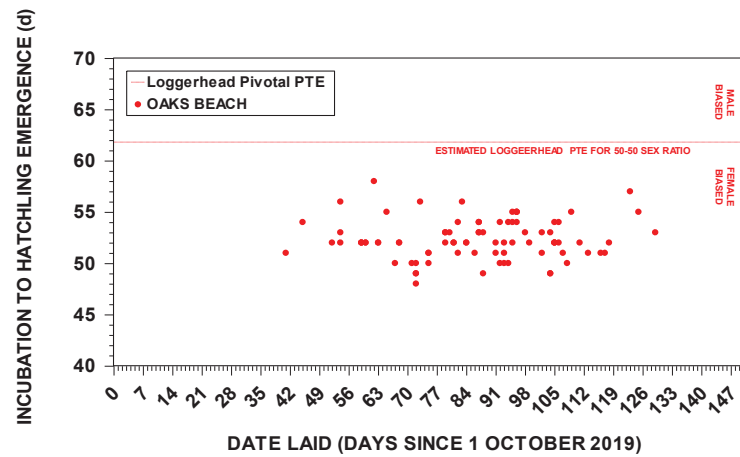
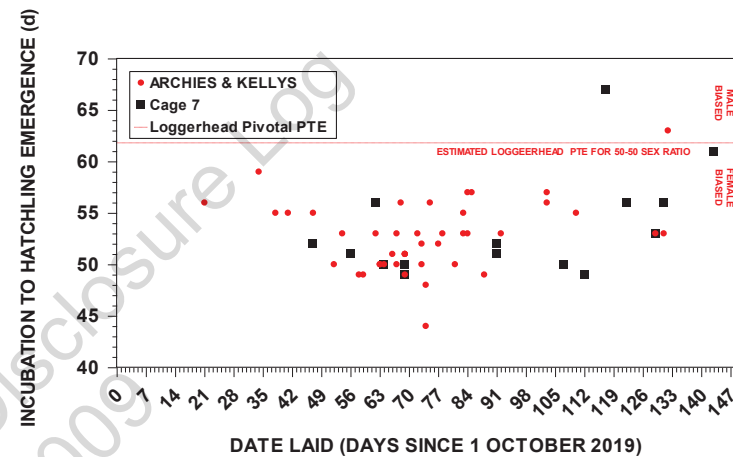


19A. Loggerhead clutches incubated on Mon Repos Beach outside of shaded hatcheries and shaded predator-proof cages



19B. Loggerhead clutches incubated on Mon Repos Beach inside shaded hatcheries and shaded predator-proof cages.

Figure 19: Incubation period from laying until hatchlings emerged onto the beach surface for Loggerhead turtle, *Caretta caretta*, clutches laid on all beaches of the Woongarra Coast during 2019-2020 breeding season.

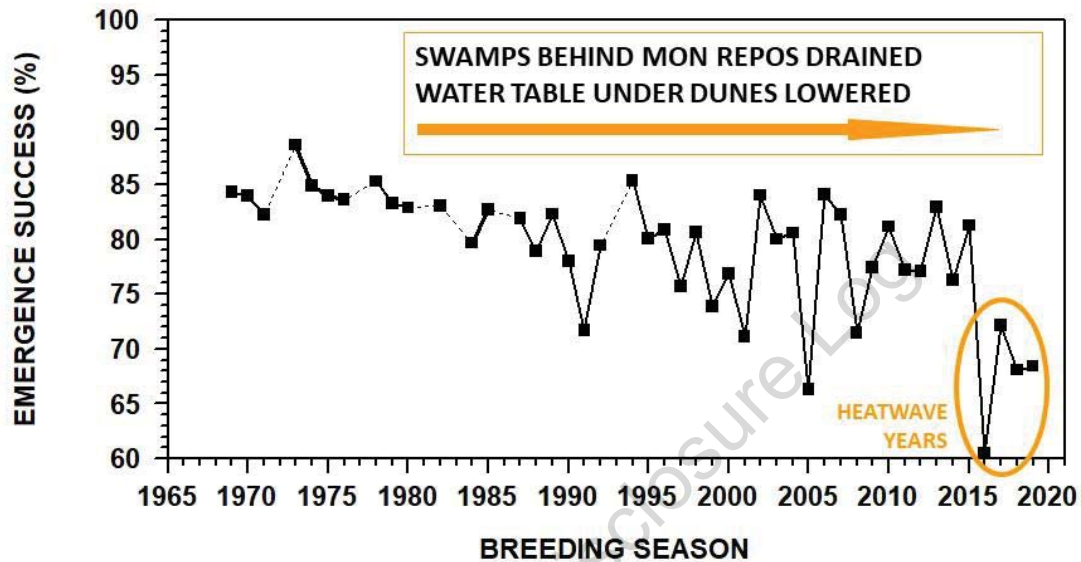


19C. Loggerhead clutches incubated on Oaks Beach.

19D. Loggerhead clutches incubated on Archies Beach and Kellys Beach outside and inside of a shaded predator-proof cage (cage 7).

Figure 19. Continued.

***Caretta caretta* INCUBATION, MON REPOS**
EMERGENCE SUCCESS
OF NATURAL UNDISTURBED CLUTCHES



Analysis of natural (undisturbed and not relocated) clutches laid on dune and slope habitat.

Figure 20: Annual variability of Loggerhead turtle, *Caretta caretta*, hatchling emergence success from naturally incubated clutches laid on the upper slope of the frontal dunes on Mon Repos Beach. Years impacted by lowering of the water table under the dunes resulting from draining of the swamp land immediately inland of the dunes are identified. Data from the last four heat wave years are circled in orange.

***Natator depressus*: WOONGARRA COAST**
TOTAL ANNUAL NESTING POPULATION: TAGGING CENSUS

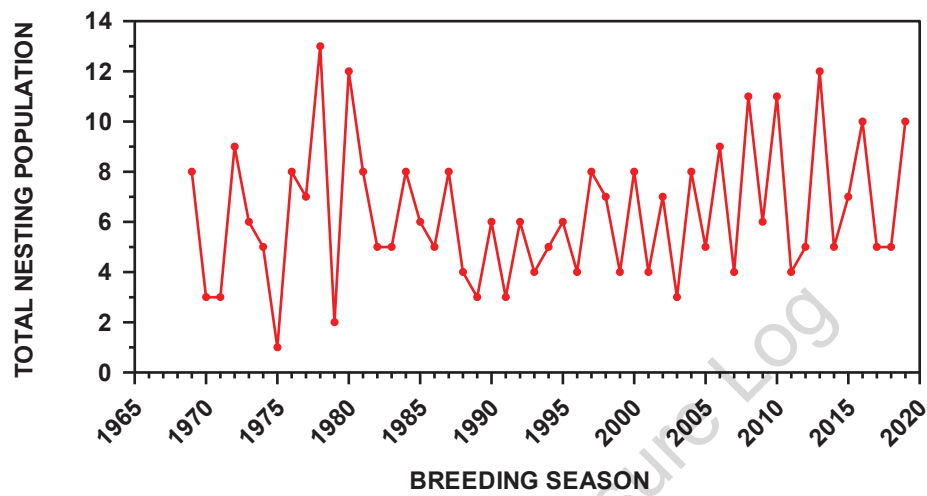


Figure 21: Summary of changing breeding numbers of Flatback turtles, *Natator depressus*, on the Woongarra Coast, 1968-2019.

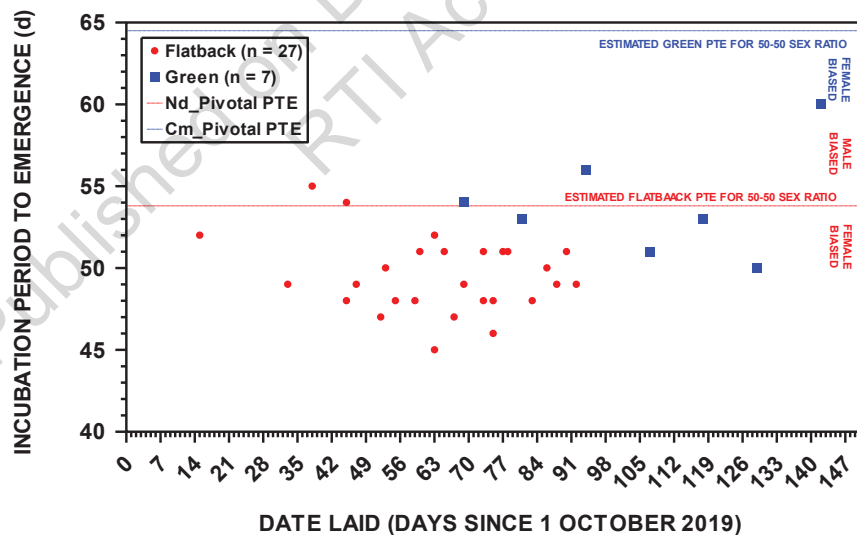


Figure 22: Incubation period from laying until hatchlings emerged onto the beach surface for Flatback, *Natator depressus*, and Green, *Chelonia mydas*, clutches laid on all beaches of the Woongarra Coast during 2019-2020 breeding season.

TABLES

Table 1: Summary of the duration of the 2019-2020 marine turtle nesting and hatchling emergence seasons on the Woongarra Coast

	<i>Caretta caretta</i> Loggerhead turtle	<i>Chelonia mydas</i> Green turtle	<i>Natator depressus</i> Flatback turtle
first nesting crawl	22 October	09 December	16 October
last nesting crawl	21 February	20 February	7 December
first hatchlings	17 December	1 February	1 January
last hatchlings	22 April	22 April	21 February

Table 2: Summary of the breeding history of the three species of marine turtles nesting on the Woongarra Coast, 2019-2020 breeding season.

	<i>Caretta caretta</i> Loggerhead turtle	<i>Chelonia mydas</i> Green turtle	<i>Natator depressus</i> Flatback turtle
1 st time tagged turtles (Primary taggings)	87	1	3
Recaptures			
Migration from foraging and 1 st time breeding	2	-	
• Returns from previous season to Woongarra Coast	269	-	7
• Remigrants with lost tags	12	-	0
• Changing nesting colony o between seasons	2	-	0
• Changing nesting colony o within season	3	-	0
TOTAL	375	1	10

Table 3: Summary of reproductive parameters of Loggerhead turtle, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season, with data pooled across the age classes.

	MEASUREMENT				Sample size
	Mean	SD	minimum	maximum	
Curved carapace length (cm)					
1 st time tagged	93.13	4.179	81.5	104.5	80
Remigrant turtles	96.23	4.486	82.4	108.4	263
All turtles	95.43	4.578	81.5	108.4	357
Other parameters					
Remigration interval (yr)	3.59	2.093	1	15	267
Re-nesting following a successful laying (d)	12.54	1.334	9	19	852
Return following an unsuccessful nesting attempt (d)	0.93	0.866	0	6	683
Eggs & clutches					
Number of clutches laid per season per female	3.70	1.114	1	6	366
Eggs per clutch	125.26	21.723	51	192	505
Yolkless eggs per clutch	0.08	0.489	0	6	505
Multi-yolked eggs per clutch	0.05	0.392	0	7	505
Egg diameter (cm)	4.039	0.133	3.20	4.40	928 eggs 93 clutches
One way ANOVA: $F_{92,835} = 27.7$; $p < 0.001$, significant between clutches					
Egg weight (g)	37.11	3.223	26.8	45.9	938 eggs 94 clutches
One way ANOVA: $F_{92,835} = 47.6$; $p < 0.001$, significant between clutches					
Nest depth to top egg	34.38	9.580	7	65	426
Nest depth to bottom	58.26	8.016	29	87	436
Incubation period to hatchling emergence (d)	53.17	2.838	41-67	847	53.17

Table 4: Curved carapace length by age class of Loggerhead turtle, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season.

Age class Breeding season	CURVED CARAPACE LENGTH (cm)				Sample size
	Mean	SD	minimum	maximum	
1 st	93.13	4.179	81.5	104.5	80
2 nd	95.52	4.812	85.8	105.0	75
3 rd	95.44	4.587	82.4	108.4	58
4 th	97.13	4.828	87.7	104.0	29
5 th	95.57	3.606	86.4	101.5	18
6 th	96.29	4.007	89.8	104.0	14
7 th	97.24	4.156	92.0	105.2	11
8 th	97.98	4.694	89.0	105.5	13
9 th	96.56	3.417	91.4	102.2	7
10 th	100.16	2.604	96.5	103.7	7
11 th	96.24	1.749	94.0	98.7	5
12 th	101.20	4.300	95.8	105.0	4
13 th	98.2	-	-	-	1
14 th	102.0	-	-	-	1
15 th	96.3	-	-	-	1

Table 5: Number of clutches laid per season by age class of Loggerhead turtle, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season.

Age class Breeding season	CLUTCHES Per SEASON				Sample size
	Mean	SD	minimum	maximum	
1 st	3.06	1.296	1	6	86
2 nd	3.75	1.002	1	6	77
3 rd	3.81	0.907	1	6	58
4 th	4.10	0.923	2	6	30
5 th	4.28	0.669	3	5	18
6 th	4.57	0.646	4	6	14
7 th	4.09	0.831	3	5	11
8 th	4.00	0.913	3	6	13
9 th	4.14	0.690	3	5	7
10 th	4.29	0.756	3	5	7
11 th	3.80	0.837	3	5	5
12 th	4.50	1.000	3	5	4
13 th	3	-	-	-	1
14 th	3	-	-	-	1
15 th	4	-	-	-	1

Table 6: Number of eggs per clutch by age class of Loggerhead turtle, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season.

Age class Breeding season	EGGS Per CLUTCH				Sample size
	Mean	SD	minimum	maximum	
1 st	113.00	19.952	51	174	114
2 nd	125.49	20.415	86	192	92
3 rd	133.23	20.254	69	177	69
4 th	127.84	20.600	90	168	37
5 th	130.11	22.262	87	172	38
6 th	125.15	27.943	57	157	13
7 th	132.31	20.918	102	191	16
8 th	129.32	25.750	80	164	22
9 th	134.40	17.755	94	158	15
10 th	131.92	20.455	90	163	13
11 th	130.29	24.005	95	161	7
12 th	145.33	11.853	131	164	9
13 th	118.67	17.954	105	139	3 (1 turtle)
14 th	-	-	-	-	-
15 th	121.75	14.127	105	137	4 (1 turtle)

Table 7: Remigration interval by age class of Loggerhead turtle, *Caretta caretta*, nesting on the Woongarra Coast, 2019-2020 breeding season.

Age class Breeding season	REMIGRATION INTERVAL (yr)				Sample size
	Mean	SD	minimum	maximum	
1 st	-	-	-	-	-
2 nd	4.23	2.400	1	15	77
3 rd	4.12	2.153	1	10	58
4 th	3.40	1.694	1	10	30
5 th	3.11	1.568	1	7	18
6 th	2.57	1.016	1	5	14
7 th	2.09	1.375	1	6	11
8 th	2.69	1.437	1	6	13
9 th	3.00	1.291	1	5	7
10 th	2.29	0.756	1	3	7
11 th	2.00	0.707	1	3	5
12 th	2.00	0.817	1	3	4
13 th	2	-	-	-	1
14 th	2	-	-	-	1
15 th	9	-	-	-	1

Table 8: Marine turtle nesting on the Woongarra Coast, 2019-2020 breeding season.

8A. Loggerhead turtle, *Caretta caretta*

Beach	NESTING CRAWLS (tracks)				
	Nesting success (%) ($\pm$ 95% CI)	Laid	did not lay	uncertain nesting success	Total tracks (% by beach) ($\pm$ 95% CI)
Oaks	42.0 $\pm$ 6.6%	89	123		212 (7.9 $\pm$ 1.0%)
Mon Repos	49.6 $\pm$ 2.1%	1106	1102	21	2229 (82.8 $\pm$ 1.4%)
Neilson Park	36 $\pm$ 11.1%	26	46		72 (2.7 $\pm$ 0.6%)
Bargara	30 $\pm$ 18.8%	7	16		23 (0.8 $\pm$ 0.3%)
Kellys	37 $\pm$ 14.7%	15	25	1	41 (1.5 $\pm$ 0.5%)
Archies	58 $\pm$ 11.0%	45	30	2	77 (2.9 $\pm$ 0.6%)
Rifle Range	-	2	1		3 (0.1%)
Innis Park	-	11	6		17 (0.6 $\pm$ 0.3%)
Elliott Heads	-	12	6		18 (0.7 $\pm$ 0.3%)
TOTAL	48.7 $\pm$ 1.9%	1314	1355	24	2693

8B. Flatback turtle, *Natator depressus*

Beach	NESTING CRAWLS (tracks)				
	Nesting success (%)	Laid	did not lay	uncertain nesting success	Total tracks (% by beach)
Oaks	-				0
Mon Repos	83%	33	7		40 (100%)
Neilson Park	-		-		0
Bargara	-	-	-		0
Kellys	-	-	-		0
Archies	-	-	-		0
Rifle Range	-	-	-		0
Innes Park	-	-	-	-	0
Elliott Heads	-	-	-		0
TOTAL	83%	33	7		40

8C. Green turtle, *Chelonia mydas*: All clutches laid by the same turtle, QA60071

Beach	NESTING CRAWLS (tracks)				
	Nesting success (%)	Laid	did not lay	uncertain nesting success	Total tracks (% by beach)
Oaks	-				0
Mon Repos	44%	7	9		16 (100%)
Neilson Park	-		-		0
Bargara	-	-	-		0
Kellys	-	-	-		0
Archies	-	-	-		0
Rifle Range	-	-	-		0
Innes Park	-	-	-	-	0
Elliott Heads	-	-	-		0
TOTAL	44%	7	9		16

Table 9: Nesting beach fidelity and change of nesting beach by 375 Loggerhead turtles, *Caretta caretta*, and 10 Flatback turtles, *Natator depressus*, and 1 Green turtle, *Chelonia mydas*, identified by tag number when ashore for nesting on the Woongarra Coast, 2019-2020 breeding season.

9A. Number of beaches visited by individual turtles

Number of beaches visited for nesting attempts by each turtle	Loggerhead		Flatback		Green	
	Number of turtles	Proportion of the total Woongarra Coast population ($\pm$ 95% CI)	Number of turtles	Proportion of the total Woongarra Coast population	Number of turtles	Proportion of the total Woongarra Coast population
1	268	71.5 $\pm$ 4.5 %	10	100%	1	100%
2	87	23.2 $\pm$ 4.3 %	-		-	
3	11	2.9 $\pm$ 1.7 %	-		-	
4	3	0.8%	-		-	
Greater than 4	Nil		-		-	

9B. Fidelity to individual beaches on the Woongarra Coast.

Beach	Loggerhead			Flatback			Green		
	Total turtles using this beach at least once	Total turtles that only used this beach	Fidelity to an individual beach (%) ($\pm$ 95% CI)	Total turtles using this beach at least once	Total turtles that only used this beach	Fidelity to an individual beach (%)	Total turtles using this beach at least once	Total turtles that only used this beach	Fidelity to an individual beach (%)
Burnett Heads			-			-			-
Oaks	24	7	29 %			-			-
Mon Repos	311	250	80.4 $\pm$ 4.4%	10	10	100%	1	1	100%
Neilson Park	7	2	28%			-			-
Bargara	-	-	-			-			-
Kellys	10	2	20%			-			-
Archies	14	5	36%			-			-
Rifle Range			-			-			-
Innis Park			-			-			-
Elliott Heads			-			-			-

Table 10: Summary of recorded egg loss during incubation on the Woongarra Coast by beaches during the 2019-2020 breeding season.

Beach	Predation by canids	Erosion of clutches	Clutches dug into by nesting turtles		
	Loggerhead	Loggerhead	Loggerhead	Flatback	Green
Oaks Beach		1			
Mon Repos		9	34		
Neilson Park		1			
Bargara					
Kellys					
Archies		1			
Rifle Range					
Innes Park		1			
Elliott Heads			1		
Woongarra Coast	0	13	35	0	0

Table 11: Summary of period to emergence, days from eggs being laid to hatchlings emerging from nests on the Woongarra Coast beaches by species and relocation history of the eggs, 2019-2020 breeding season.

Beach	Period to Emergence (d)			
	Mean	SD	Range	Sample size
FLATBACK				
Mon Repos	49.52	2.293	45 - 55	27
GREEN				
Mon Repos	53.86	3.338	50 - 60	7
LOGGERHEAD				
Combined beaches	53.17	2.838	41 - 67	847
Mon Repos				
On beach	52.97	2.783	41 - 65	601
Hatchery 1	54.95	1.847	52 - 59	42
Hatchery 2	55.82	1.601	54 - 58	11
Cage 1	55.5	1.505	54 - 58	18
Cage 2	57.33	1.633	55 - 60	6
Cage 3	52.89	3.756	49 - 62	9
Cage 4	57.14	1.069	56 - 58	7
Oaks - Beach	52.33	1.948	48 - 58	85
Archies Beach				
On beach	51.00	3.229	44 - 57	15
Cage 7	53.50	5.080	49 - 67	14

Table 12: Summary of hatching success of eggs and hatchling emergence from nests on the Woongarra Coast beaches by species and relocation history of the eggs during the 2019-2020 breeding season.

Beach	Subset	Hatching Success (%)				Emergence Success (%)			
		Mean	SD	Range	Sample	Mean	SD	Range	Sample
FLATBACK									
Mon Repos	Combined	70.13	23.588	8.57 – 100.0	26	62.43	26.278	0 – 94.4	26
GREEN									
Mon Repos	Combined	90.50	7.616	77.0 – 95.0	5	87.48	9.910	70.1 – 94.1	6
LOGGERHEAD									
Mon Repos	Natural nests	75.64	23.04	0 – 100	711	68.42	27.04	0 – 100	711
	Relocated to dune	69.32	25.09	0 – 98.8	193	62.92	28.31	0 – 99.8	193
	Hatchery 1	68.18	21.99	0.0 – 95.5	54	64.22	22.77	0 – 95.5	54
	Hatchery 2	71.05	24.19	15.7 – 97.9	11	64.18	24.34	15.7 – 96.8	11
	Cage 1	74.52	21.36	0 – 96.6	26	71.77	20.4	0 – 93.6	22
	Cage 2	73.46	13.38	50.0 – 89.0	8	71.35	44.3	44.3 – 88.2	8
	Cage 3	73.32	23.58	29.3 – 99.2	8	71.95	24.57	26.1 – 99.2	8
	Cage 4	86.63	10.24	66.9 – 96.2	8	86.43	10.29	66.9 – 96.2	8
Oaks	On beach	64.30	25.01	0.8 – 96.9	89	60.53	26.23	0.7 – 95.1	89
Archies	On beach	70.15	27.30	0 – 99.2	57	64.78	29.81	0 – 99.15	57
	Cage 7	52.99	27.19	5.2 – 87.1	18	50.77	27.48	4.5 – 85.6	18

Table 13: Summary of reproductive parameters of Flatback turtle, *Natator depressus*, nesting on the Woongarra Coast, 2019-2020 breeding season, with data pooled across the age classes.

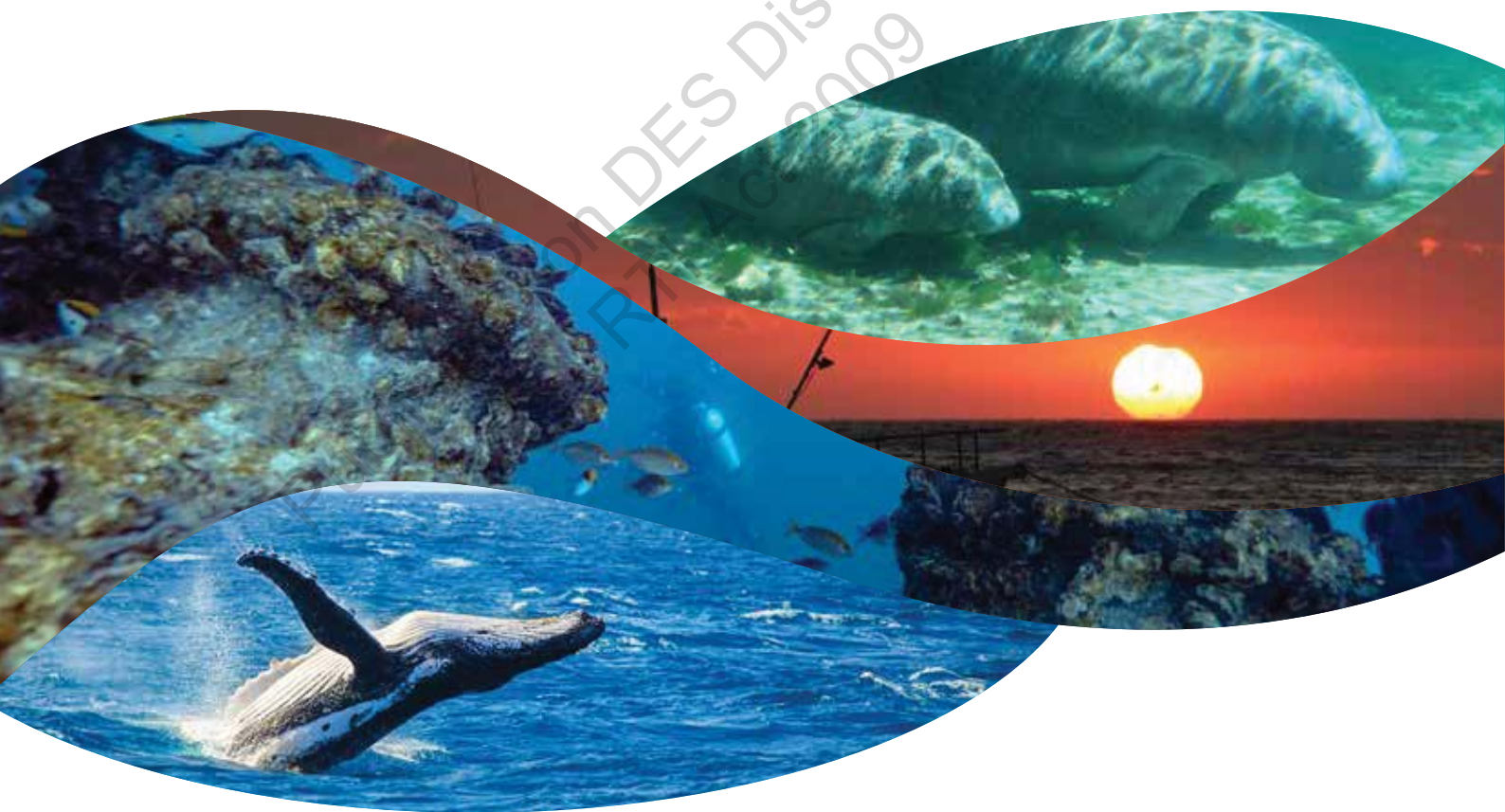
	MEASUREMENT				Sample size
	Mean	SD	Minimum	Maximum	
Curved carapace length (cm)					
1 st time tagged	91.70	1.819	90.6	93.8	3
Remigrant turtles	93.36	2.802	89.4	96.3	7
All turtles	92.86	2.571	89.4	96.3	10
Other parameters					
Remigration interval (yr)	3.29	0.756	2	4	7
Re-nesting following a successful laying	14.35	1.668	12	19	23
Return following an unsuccessful nesting attempt	1.00	0.817	0	2	7
Eggs & clutches					
Number of clutches laid per season per female	3.30	0.675	2	4	10
Number of eggs per clutch	55.19	6.884	41	69	27
Egg diameter (cm)	5.14	0.148	4.72	6.39	240 eggs 24 clutches
	One way ANOVA: $F_{23,216} = 7.72$; $p < 0.001$, significant between clutches				
Egg weight (g)	74.62	4.760	57.3	85.5	260 eggs 26 clutches
	One way ANOVA: $F_{25,234} = 21.5$; $p < 0.001$, significant between clutches				
Nest depth to top egg	32.60	11.519	10	65	28
Nest depth to bottom	54.93	7.892	42	80	23
Incubation period to hatchling emergence (d)	49.51	2.293	45	55	27
Hatching success of eggs (%)	70.13	23.59	8.6	100	26
Hatchling emergence success from nest (%)	62.43	26.28	0	94.4	26

Table 14: Summary of reproductive parameters of Green turtle, *Chelonia mydas*, nesting on the Woongarra Coast, 2019-2020 breeding season, with data pooled across the age classes. These data were collected from the seven consecutive clutches laid by one turtle, QA60071.

	MEASUREMENT				Sample size
	Mean	SD	minimum	maximum	
Number of eggs per clutch	83.8	5.59	76	90	5
Egg diameter (cm)	4.36	0.204	4.12	4.92	70 eggs 7 clutches
One way ANOVA: $F_{92,835} = 27.7$; $p < 0.001$, significant between clutches					
Egg weight (g)	43.70	2.259	37.7	47.3	70 eggs 7 clutches
One way ANOVA: $F_{6,63} = 6.4$; $p < 0.001$, significant between clutches					
Nest depth to top egg	44.5	9.75	33	54	4
Nest depth to bottom	61.0	8.26	52	80	4
Incubation period to hatchling emergence (d)	53.9	3.34	50	60	7
Hatching success of eggs (%)	90.50	7.62	77.0	95.0	5
Hatchling emergence success from nest (%)	87.48	9.91	70.1	94.1	5

Great Sandy Marine Park Zoning Plan Review

Consultation summary of the
*Great Sandy Marine Park Discussion
Paper—Zoning Plan Opportunities*



The Department of Environment and Science is undertaking a comprehensive review of the Great Sandy Marine Park (GSMP) Zoning Plan.

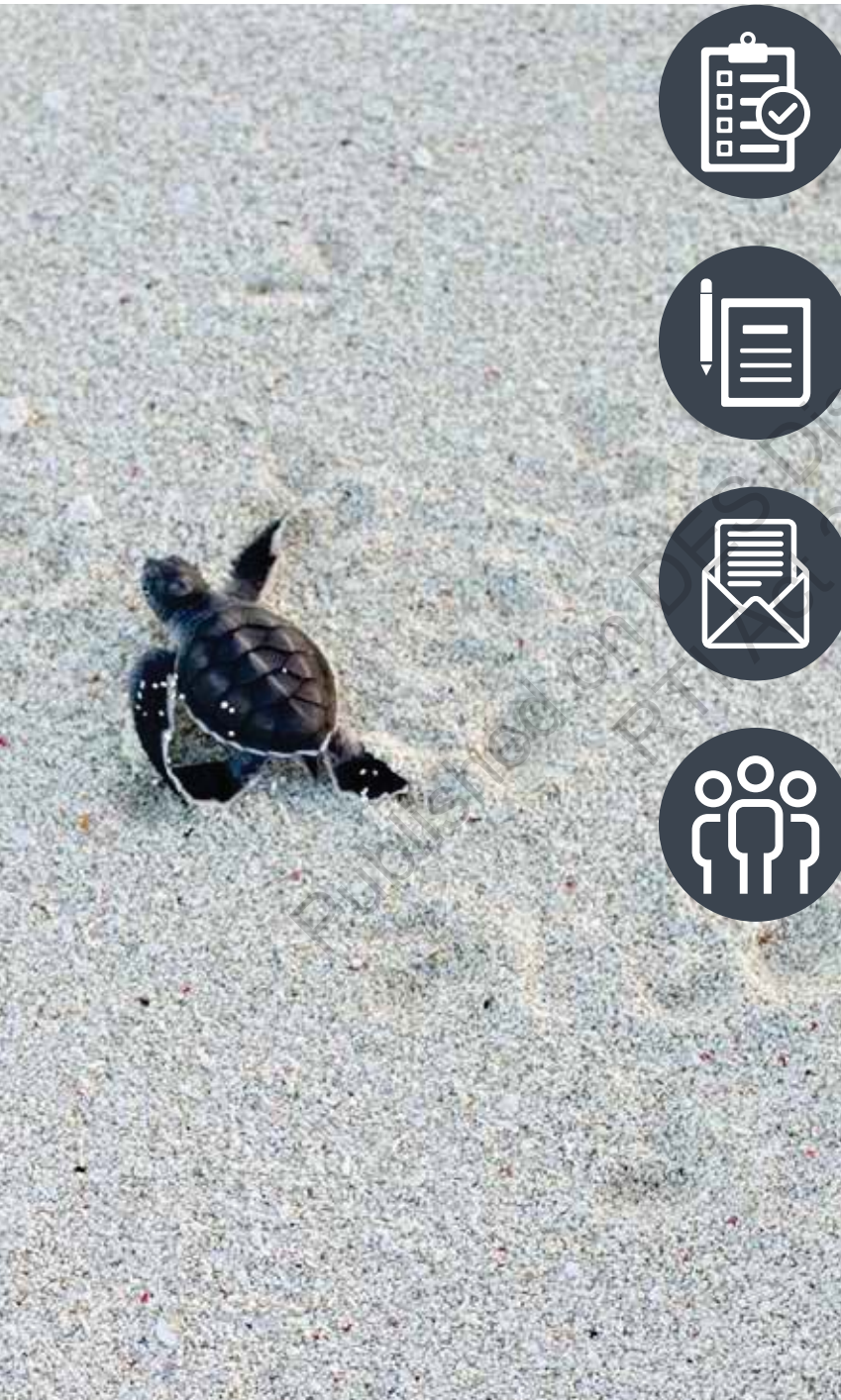
This is the first time that the management of the marine park has been reviewed since it was established in August 2006.

A significant component of the review has been to seek feedback from stakeholders on a range of measures suggested to achieve an appropriate balance between conservation and use of the marine park. The *Great Sandy Marine Park Discussion Paper—Zoning Plan Opportunities* was a key tool to seek public input on the review process. The discussion paper is available at www.des.qld.gov.au.

Feedback showed a high level of interest on a wide range of issues and in many cases stakeholder views differ. These are being considered by the department in the preparation of a revised draft zoning plan.

Who provided feedback

- First Nations peoples
- Commercial fishing industry
- Conservation groups
- Members of the public
- Tourism bodies
- Research institutions
- Recreational fishers
- Local Government
- Community groups
- State Government
- Recreational user groups



What the feedback told us

Note: Figures quoted throughout the report (e.g. X% of respondents) and graphs illustrating responses are typically drawn from survey responses. In some instances, not all respondents answered all questions—in these cases, the percentages reported represent the proportion of individuals who responded to that question. The total number of respondents who answered each question is indicated on the relevant graph. In cases where the term ‘written responses’ is used, numbers associated with this are drawn from the free text field in the survey and separate written submissions.

Cultural heritage

- Some First Nations peoples and several members of the public supported the implementation of additional specific provisions to protect and support the management of First Nations peoples’ cultural values within the marine park. These include protecting shellfish middens by managing wash from vessels, e.g. Go Slow Areas, and improved mapping of cultural heritage resources (e.g. shell middens, fish traps). Further consultation with First Nations peoples will continue to be undertaken to inform the development of the draft revised zoning plan.



Midden shells (Fraser Island)
© Queensland Government

Marine National Park (‘green’) zones

- Forty-three (43) written responses suggested protection of at least 10% of the marine park in green zones, including a joint submission made by 23 organisations and businesses. This suggestion was also reflected by over 2,000 people signing a petition organised by the Australian Marine Conservation Society.
- There was also support for protecting more areas of coral and seagrass habitat (Figure 1).
- Other suggestions made by respondents included:
 - ▶ Ensuring that a proportion of each habitat type found in the marine park is protected in a green zone.
 - ▶ Applying best practice reserve design principles including reserve size and spacing, replication, and placing to promote ecosystem connectivity
 - ▶ Ensuring that the full extent of the unique gastropod reef off Rooney Point is included in a green zone.
 - ▶ Providing refugia for species being impacted by climate change through increasing the area of green zones.
 - ▶ Introducing new green zones at certain locations in the marine park, including around the ex-HMAS Tobruk, Seary’s Creek and along the foreshore between Moon Point and Black Creek on K’gari (Fraser Island).
- Forty-seven per cent (47%) of survey respondents supported amending the boundaries of the green zones around Turkey, Bookar and Walsh Islands in the Great Sandy Strait to provide greater protection to the habitats in the area, while 49% did not support these changes (Figure 2).
- While there were respondents that suggested an increase in green zones, there were other respondents that suggested a reduction in the number of green zones to allow greater access for recreational fishers.
- Seventy-six per cent (76%) of survey respondents and 50 written submissions were opposed to establishing a green zone in Baffle Creek (Figure 3) because of potential impacts on tourism and real estate values in the area. Almost 4,000 people signed one of two petitions in the Baffle Creek community opposing a green zone in this location.

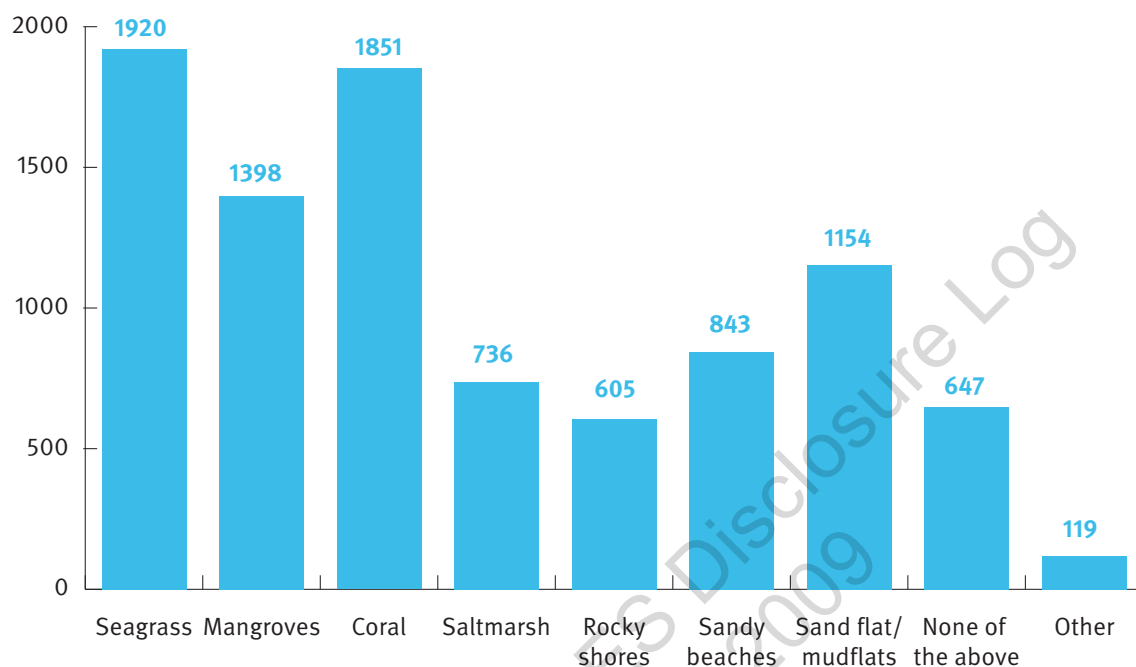


Figure 1: Survey responses for habitat types requiring greater protection in GSMP

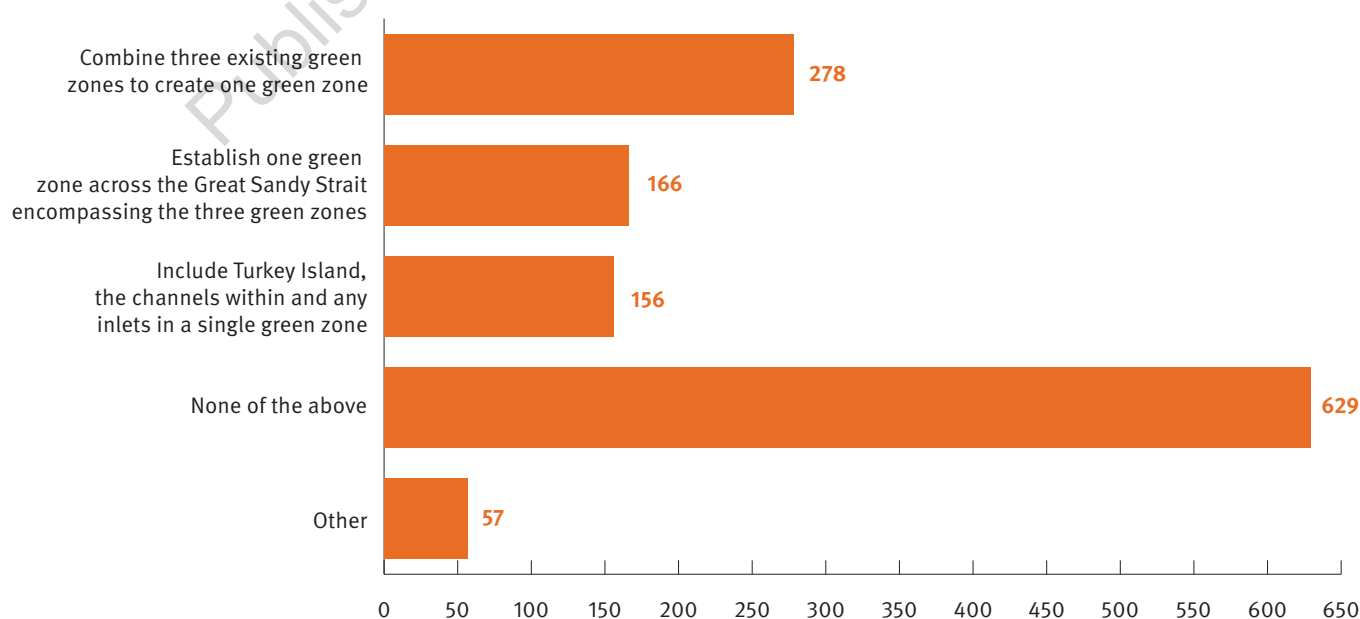


Figure 2: Survey responses on options to consider for amending the boundaries of the existing green zones in the vicinity of Turkey, Bookar and Walsh Islands to enhance management and species and habitat protection

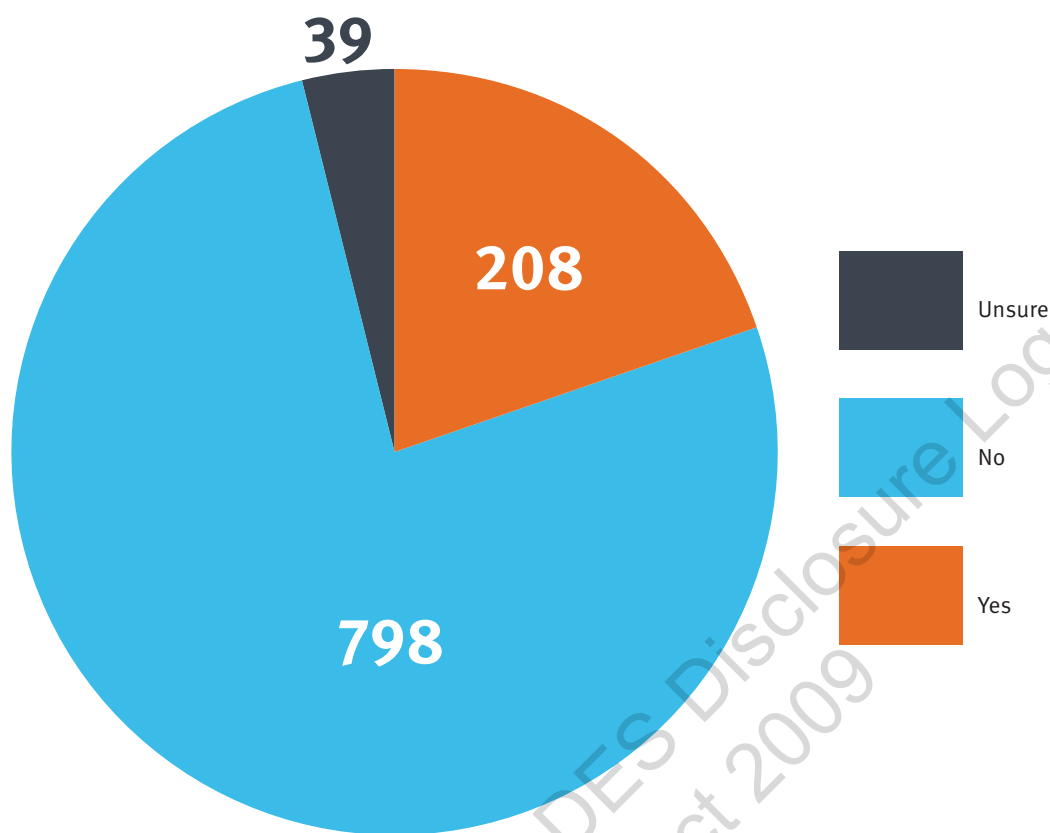


Figure 3: Survey responses to whether parts of Baffle Creek should be included in a green zone



Coral habitat and no-anchoring areas

- Fifty-eight per cent (58%) of survey respondents supported introducing no-anchoring areas to protect coral habitats from anchor damage in high-use areas (Figure 4).
- There were mixed views about introducing no anchoring areas rather than green zones to protect coral at locations such as Gatakers Bay, Point Vernon and the reefs near Pialba and Scarness (Figure 5).
- There were a small number of requests to install moorings for dive boats at Wolf Rock to prevent anchor damage.
- Suggestions were made to use buffer zones, rather than green zones to protect coral reefs which would allow fishing for pelagic fish species.
- Almost 63% of survey respondents supported improving protection of Four Mile Reef (Figure 6). Several scientists indicated that it is the only example in the marine park of a coral reef with a vertical and continuous calcareous structure that also supports a unique coral assemblage.
- There were a number of survey respondents (34%) that did not support introducing greater protection at Four Mile Reef, with some stating that it is a popular recreational fishing spot and it is used by commercial fishers to collect marine aquarium fish.
- It was also suggested that commercial fishers be exempt from any anchoring restrictions, especially those in the marine aquarium fish fishery.

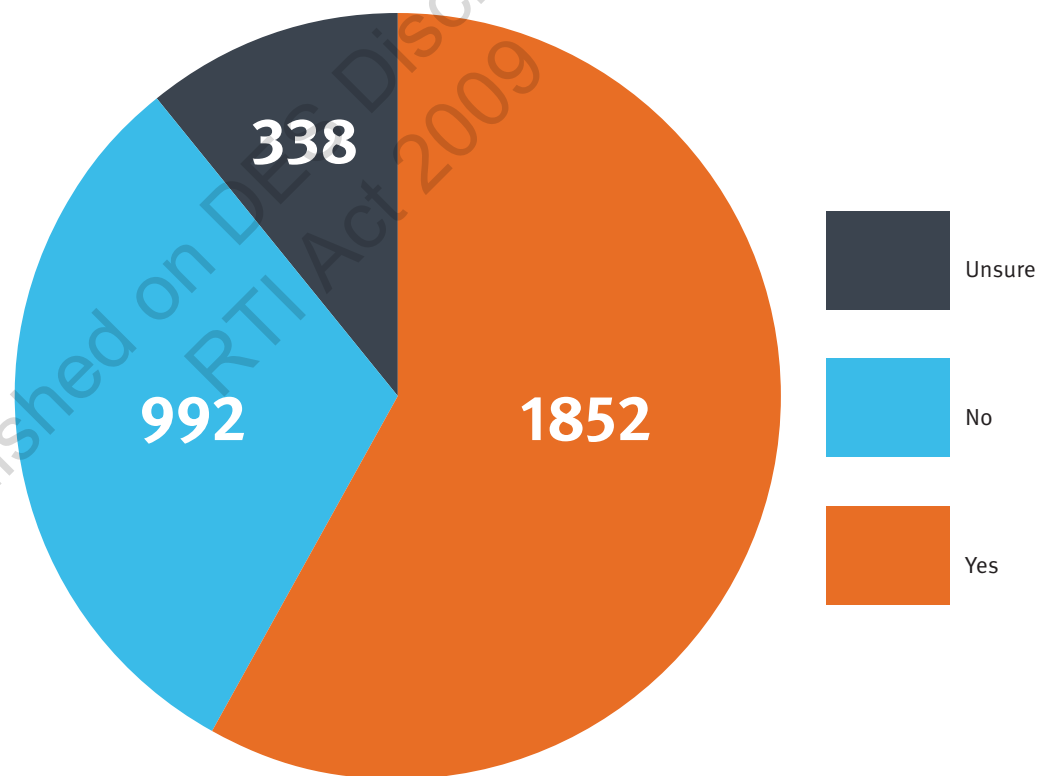


Figure 4: Survey responses for no-anchoring areas to be introduced to protect coral communities



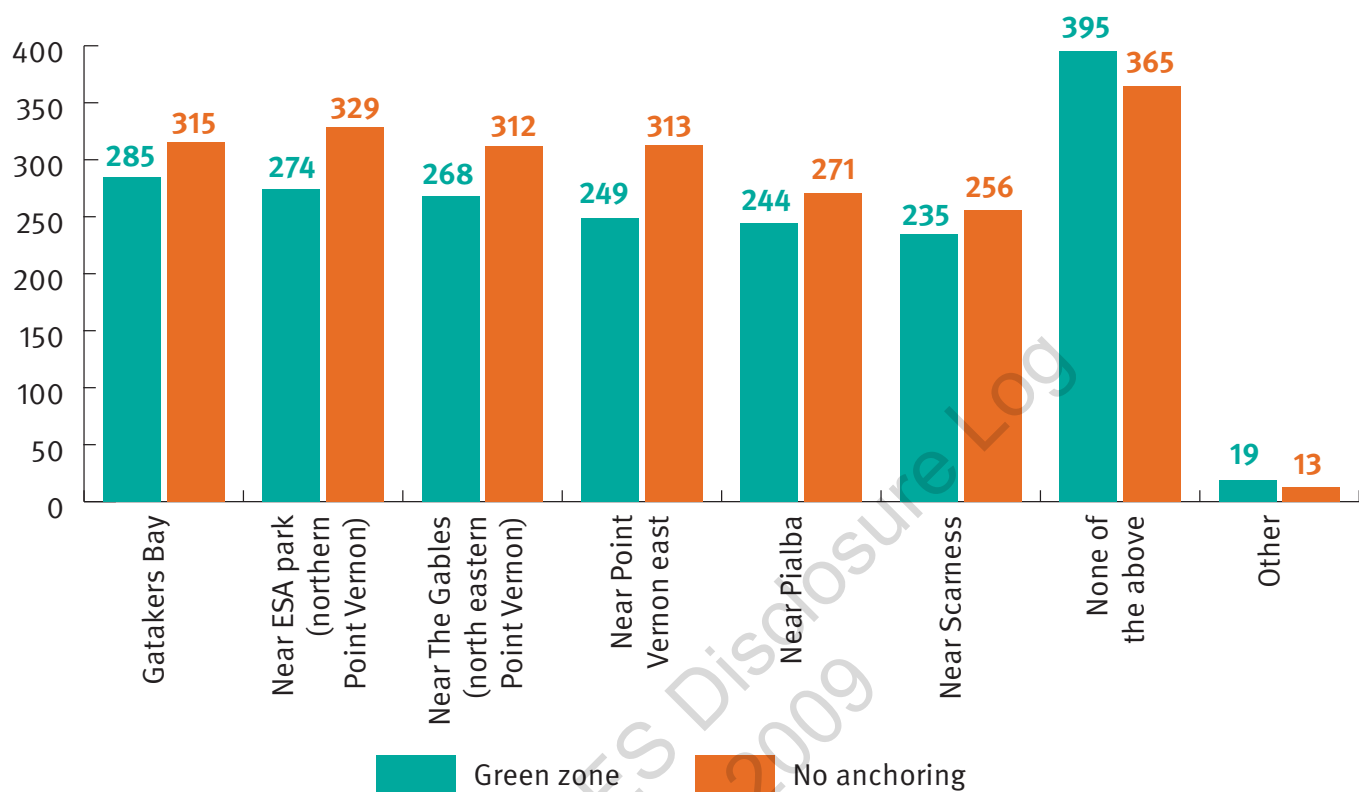


Figure 5: Survey response on options to protect coral communities at selected locations

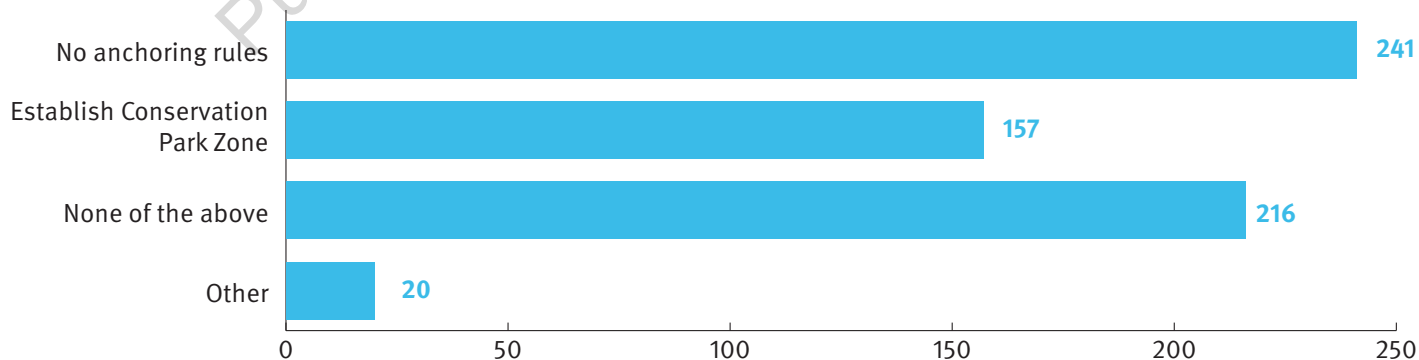


Figure 6: Survey responses on management options for Four Mile Reef



Grey nurse shark
© Amanda Delaforce

Threatened species

Grey nurse shark

- There were mixed views on whether there should be increased protections for Grey nurse sharks in the marine park. At a broad level, 30% of survey respondents indicated that there should be increased protection, while 51% indicated that increased protection was not required (Figure 7).
- A small number of respondents suggested an increase in the size of the green zone around Wolf Rock to better protect Grey nurse sharks from the impacts of fishing at this significant aggregation site.
- In a joint submission, 23 organisations and businesses suggested expanding the current buffer zone around Wolf Rock to increase protection for Grey nurse sharks while allowing recreational fishers to troll for pelagic fish species.
- A small number of respondents indicated that an expansion of the green zone around Wolf Rock is likely to impact commercial line fishers who fish for mackerel off Double Island Point.
- One hundred and twelve (112) survey respondents supported restricting scuba diving at Wolf Rock to marine park permit holders.

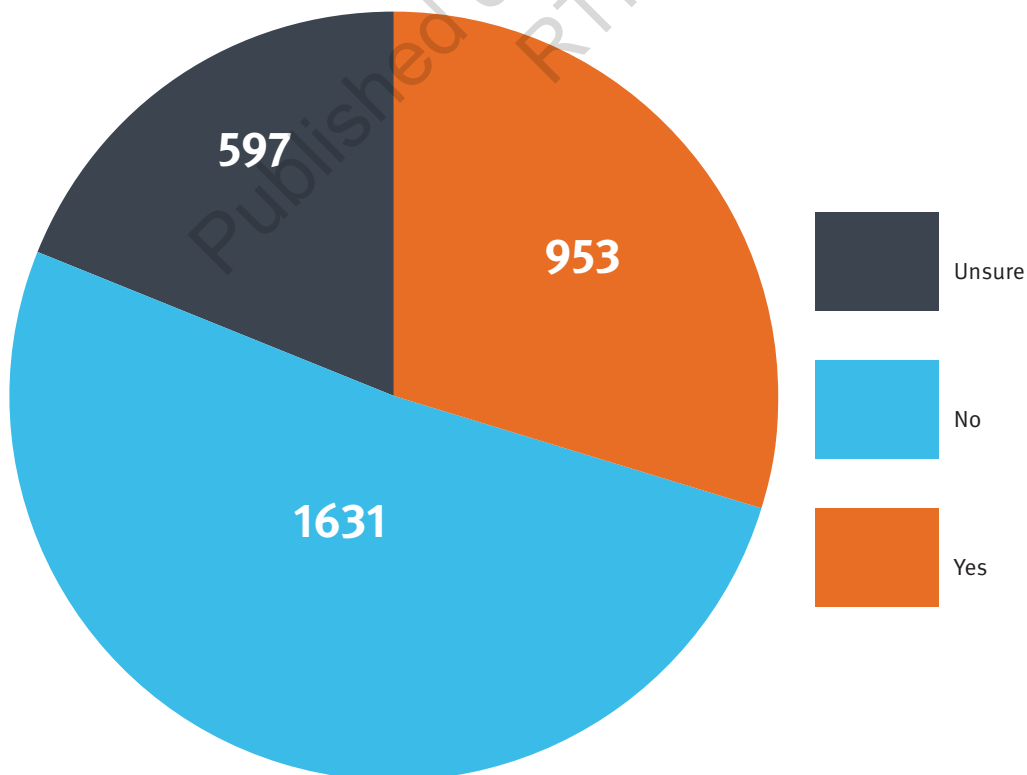


Figure 7: Survey responses on whether more protection is required for Grey nurse sharks



Hatchling
© Tourism and Events Queensland

Turtles and Dugong

- Fifty-four percent (54%) of survey respondents indicated that there should be more Go Slow Areas in the marine park to protect turtles and dugong. Respondents indicated that current green zones, Conservation Park Zones and Go Slow Areas are inadequate to protect turtles and dugong based on current species distribution maps.
- Respondents suggested increasing the size of several existing Go Slow Areas and establishing new areas in key shallow-water turtle and dugong habitats to minimise risk of boat strike.
- Respondents supported introducing beach access restrictions and a Go Slow Area for vessels similar to Mon Repos to protect nesting turtles on Moore Park Beach (Figure 8).
- Some respondents requested changing the zoning to prohibit trawling in the vicinity of Moore Park Beach to protect nesting turtles and hatchlings.
- Almost 20% of survey respondents supported the establishment of a green zone at Mon Repos, while 64% of respondents supported other potential changes to existing zoning plan rules to improve protection for turtles at Mon Repos (Figure 9).
- Other suggestions made by respondents include introducing restrictions to prevent domestic animals and vehicles from accessing the beach between Littabella Creek and Baffle Creek to protect nesting turtles, and extending the seasonal start time of the designated Mon Repos Area to allow for changes in the nesting pattern of turtles at Mon Repos.
- Some respondents requested an increase in the size of the seasonal Go Slow Area at the northern end of K'gari (Fraser Island) stating it is currently inadequate to protect nesting turtles while others sought the removal of this Go Slow Area stating it is a potential safety issue for boaters returning from offshore in adverse weather conditions.
- A small number of written submissions indicated that Go Slow Areas affect commercial fishing operations and suggested that these areas should not apply to commercial fishers operating under an agreed Code of Practice.

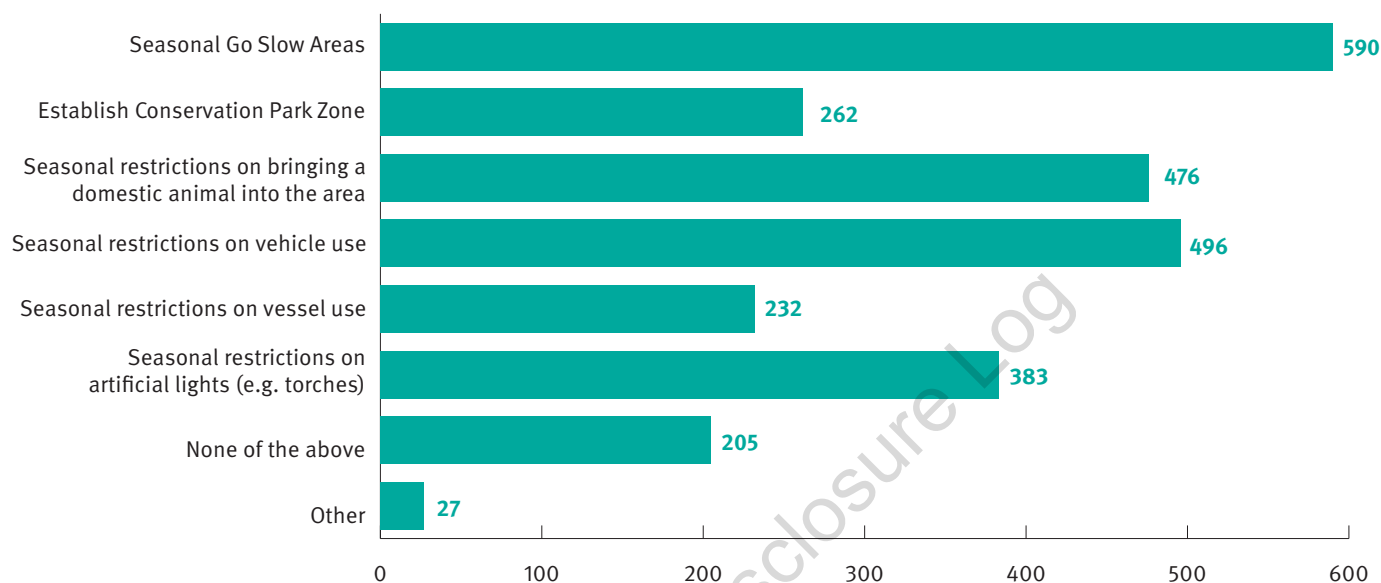


Figure 8: Survey responses on options to enhance the protection of nesting turtles, hatchlings and their habitat along Moore Park Beach

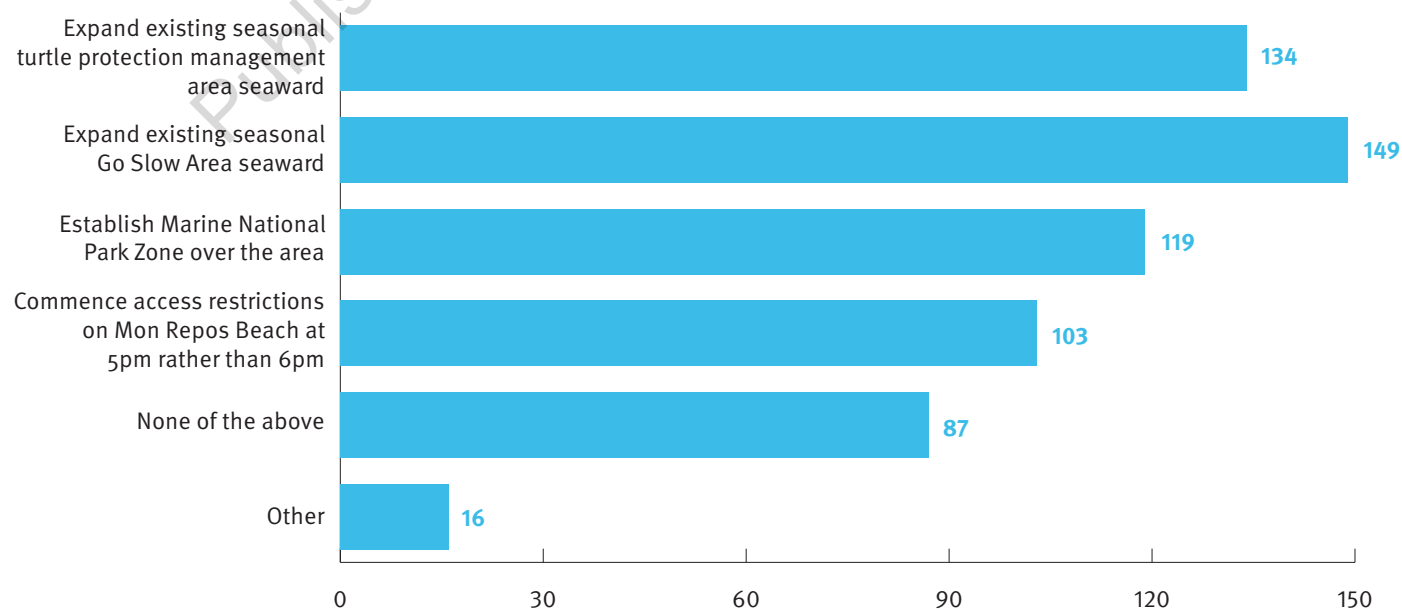


Figure 9: Survey responses on options to enhance the protection of turtles at Mon Repos



Curlews
© Queensland Government

Shorebirds

- Forty-four percent (44%) of survey respondents supported introducing general park-wide rules to protect shorebirds and their habitat from intentional disturbance. (Figure 10).
- Several ornithologists suggested introducing seasonal restrictions at key high tide migratory shorebird roost sites.

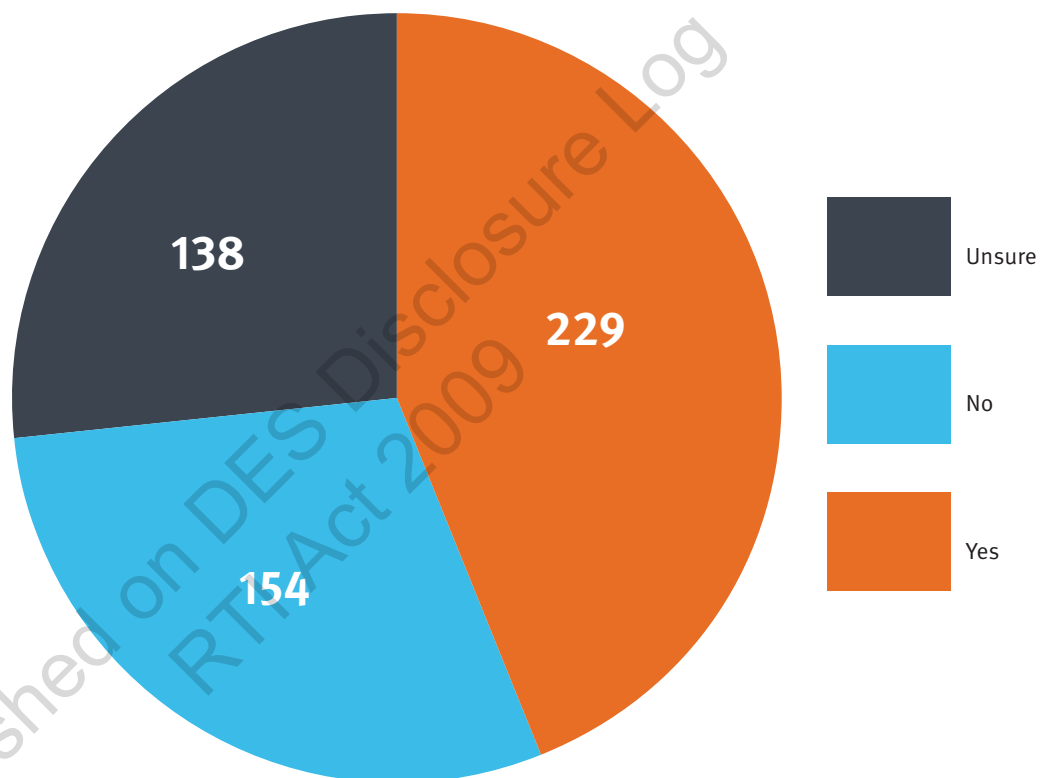


Figure 10: Survey responses for adoption of park wide shorebird protection rules similar to those in place in Moreton Bay Marine Park

Humpback whales

- A small number of written responses requested better protection for humpback whales in the marine park, including:
 - ▶ introducing a Go Slow Area in Platypus Bay to protect whales from boat strike during their annual migration
 - ▶ providing greater protection of humpback whale habitat in Hervey Bay in recognition of the importance of the area to the reproductive success of humpback whales
 - ▶ prohibiting crabbing in Platypus Bay during whale season
 - ▶ managing and monitoring swim-with-whale programs and general whale watching tourism.

Designated Great Sandy Area

- Many respondents argued that the underlying Conservation Park Zone should be retained, but the Great Sandy Area rules should be amended or removed to protect wildlife from entanglement with fishing nets, and to promote tourism and recreational fishing experiences by increasing fish stocks of species being depleted by the commercial net fishery. Eighty three percent (83%) of survey respondents indicated that the Great Sandy Area rules should either be removed or amended (Figure 11).
- Over 20,000 people signed a petition initiated by the Fraser Coast Fishing Alliance requesting that the Great Sandy Area be removed from the marine park. It was argued that removing the Great Sandy Area and 'buying out' commercial fishing licences was important because commercial netting does not align with the objectives of the underlying Conservation Park Zone. The petition organised by the Australian Marine Conservation Society also requested that the Great Sandy Area be removed.
- Further, respondents argued that removing the commercial net fishing pressure would improve the recreational fishery and boost tourism in the region, generating economic benefits that would outweigh the existing value of the commercial net fishery.
- Conversely, others argued for not changing the current zoning plan provisions which allow the continuation of the existing commercial net, line and crab fisheries within the waterways of the Great Sandy Area and requested an investigation of alternative management options to overcome the perception that commercial fishing in these waterways is an unintended 'anomaly' in the zoning plan. This was requested through more than 75 written responses provided by commercial fishers, industry representatives and seafood processing businesses.
- These respondents argued that continuation of the existing marine park provisions supports the industry by:
 - ▶ providing fresh local seafood to the general public who do not fish
 - ▶ increasing the value of fishing businesses to the regional economy through direct employment
 - ▶ creating business activity which in turn supports local industries and other businesses
 - ▶ recognising the long history of stewardship and sustainable fishing within these waterways and the important contribution that commercial fishing delivers to the cultural and social fabric of the region, e.g. the annual Hervey Bay Seafood Festival, which pre-dates the establishment of the marine park.

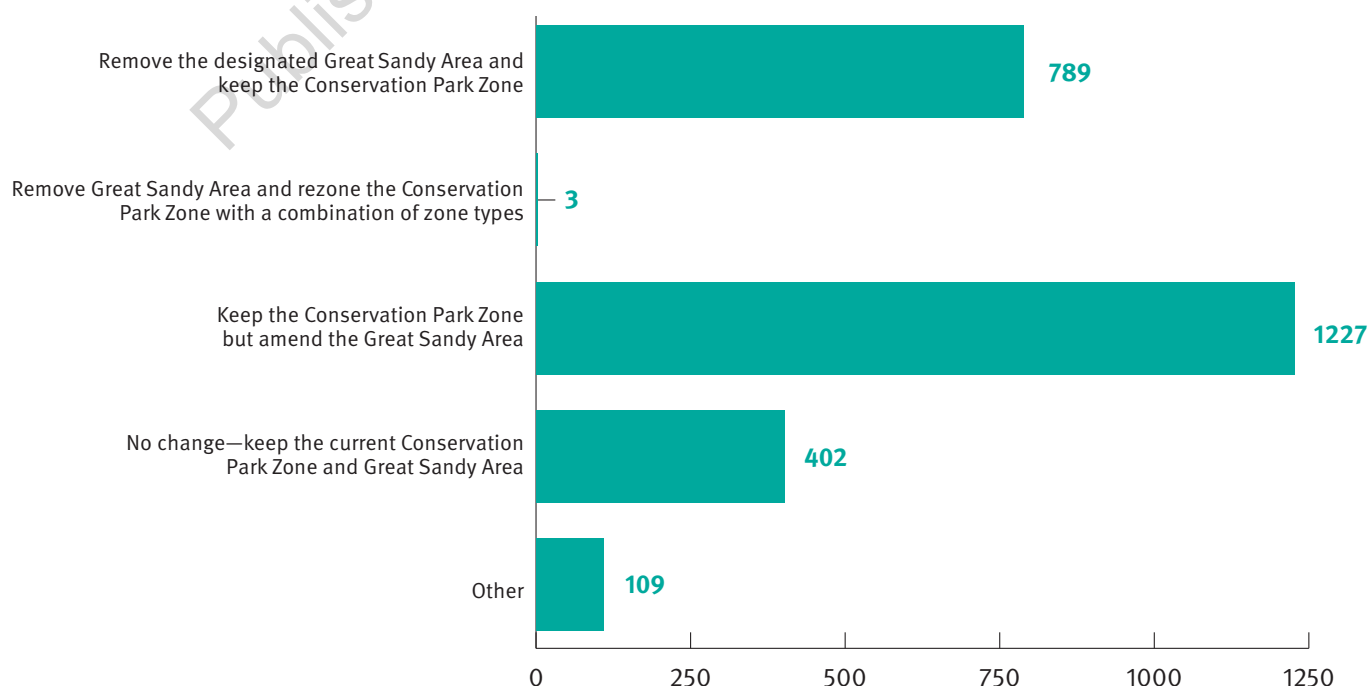


Figure 11: Survey responses on options for the future management of the designated Great Sandy Area



Fishing

- Thirty-six (36) written responses suggested establishing more artificial reefs to promote recreational fishing.
- Three hundred and forty-three (343) respondents requested the removal of commercial netting from everywhere in the marine park.
- Twenty-four (24) and 82 respondents requested the removal of trawling and commercial crabbing, respectively, from the marine park.
- Other respondents requested the removal of commercial fishing activities such as trawling, netting and crabbing from specific locations in the marine park.
- Respondents supported introducing additional restrictions on commercial bait netting in Conservation Park Zones (Figure 12).
- One written submission requested changing the zoning to prohibit commercial trawling from partially smooth waters in Hervey Bay as well as changing the zoning on K'gari (Fraser Island) ocean beaches to prohibit commercial netting.
- A small number of written submissions sought to maintain the non-conforming use provisions especially for the marine aquarium fish fishery stating the continued reliance on the green zone at Little Woody Island for commercial export markets.
- However, the majority of respondents supported phasing out the following non-conforming commercial fishing activities in the marine park (Figure 13):
 - beam trawling in the Mary River
 - coral collecting in the vicinity of Woody Island
 - marine aquarium fish fishery in the Little Woody Island green zone
 - crab fishing in the Great Sandy Strait, Baffle Creek, Elliott River and Burrum River.

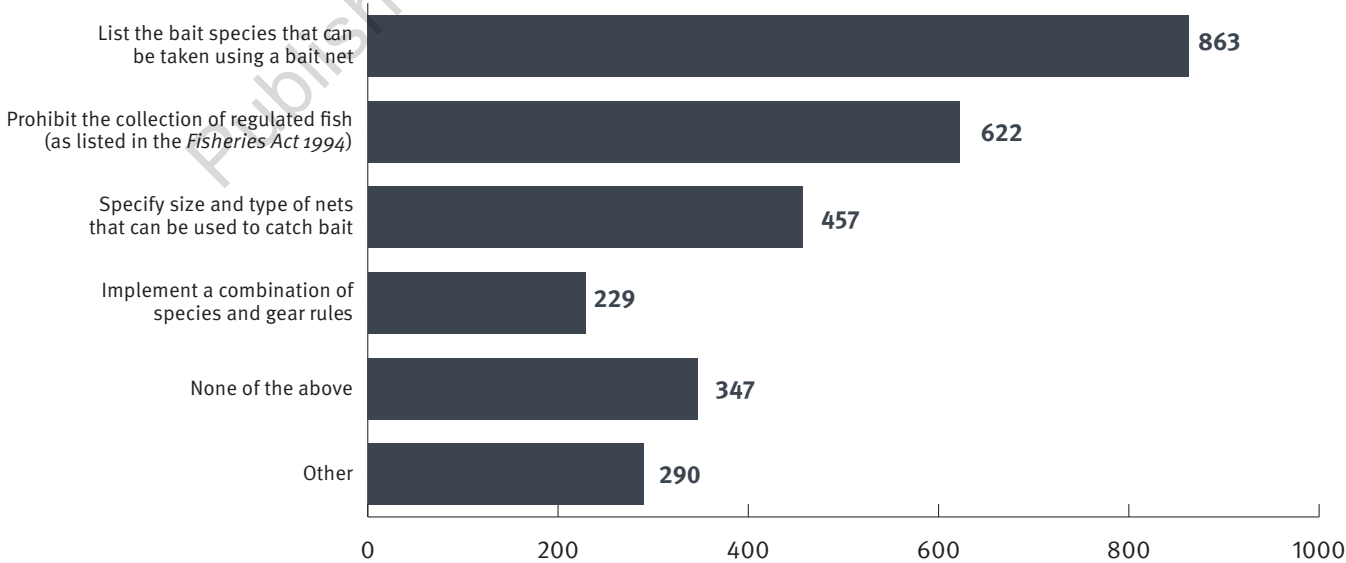


Figure 12: Survey responses on options to manage commercial bait netting in Conservation Park Zones

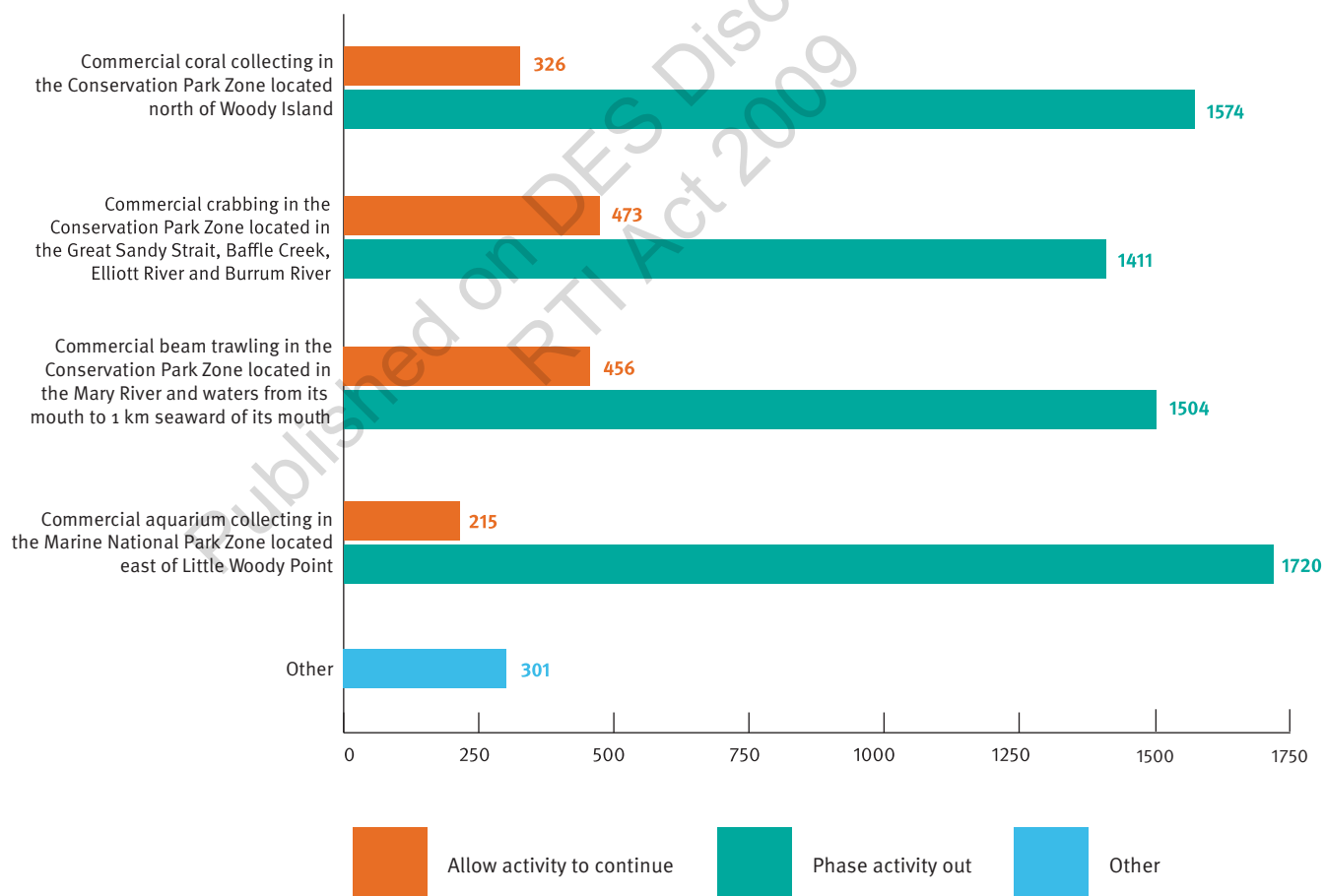


Figure 13: Survey responses on options to manage existing commercial non-conforming use fisheries

Use

- Respondents indicated that recreational fishing is the primary activity they support occurring in the marine park, followed by passive recreational activities such as swimming and non-motorised water sports (Figure 14).
- Fifty-two per cent (52%) of survey respondents support establishing a Go Slow Area to minimise impacts on amenity values and reduce disturbance to shorebirds, turtles and dugong in Eli Creek to the west of Point Vernon, while 32% supported allowing only non-motorised water sports in the Creek.
- Twelve (12) written responses sought the removal of the requirement for recreational hovercraft to require permission to operate in the marine park, which was also reflected by 393 signatures on the Queensland Sporting Hovercraft Club petition. However, other respondents called for hovercraft to be prohibited from, or better managed, within the marine park.
- A small number of respondents called for aquaculture and fish farms to be prohibited in the marine park and for motorised vessels to be prohibited in certain locations.

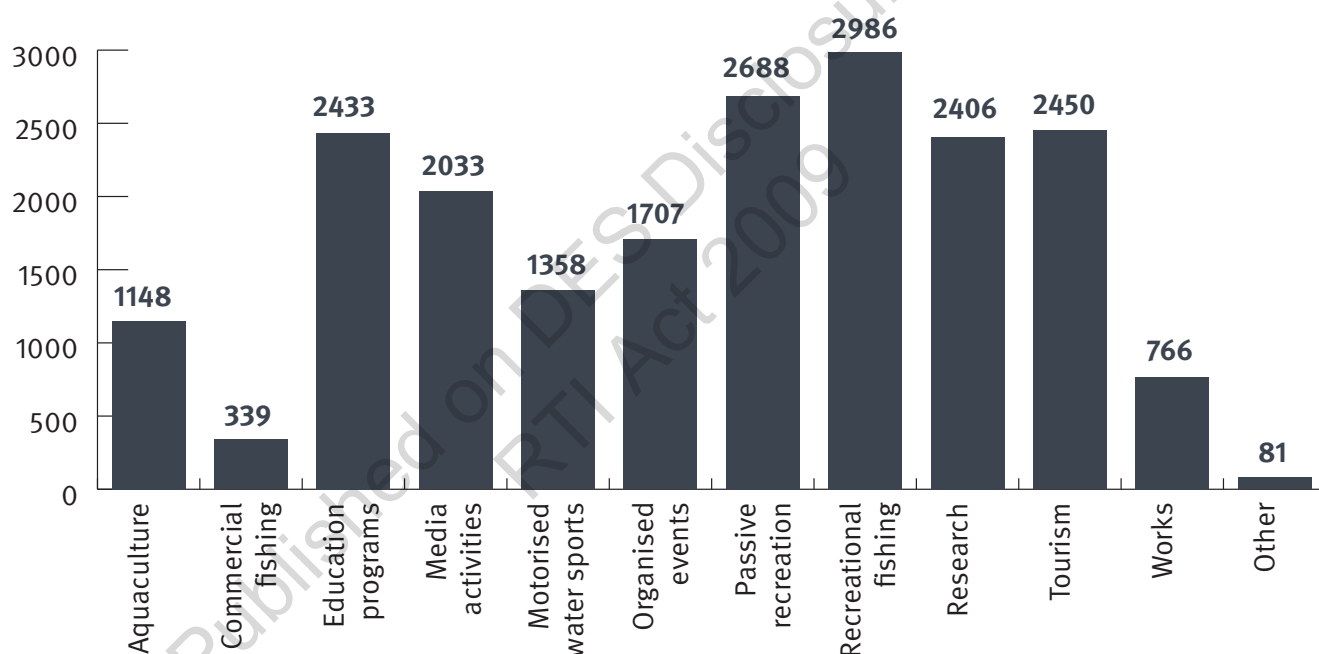


Figure 14: Survey responses indicating support for activities to occur in GSMP



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Coastal development

- Through survey responses and written submissions, respondents expressed a range of views on private structures such as jetties and boat ramps, including streamlining the authorisation process for private structures, prohibiting private structures, minimising the number of private jetties and boat ramps, and adjusting the zoning in places to allow for particular structures (Figure 15).
- Respondents also expressed a range of views on dredging, from prohibiting the activity to proposals for dredging in particular locations (e.g. Wanggoolba Creek) for specific purposes.
- Thirty-two percent (32%) of survey respondents (Figure 15) and some written submissions supported a change in the zoning at selected locations (e.g. adjacent to developed foreshores) to allow erosion management for climate change resilience works by local government.
- There were a range of location specific changes supported and identified, including:
 - changing the zoning of Dayman Spit so sand can be used as a source of nourishment material for Hervey Bay beaches (Figure 15)
 - removing the non-conforming use rules that allow dredge spoil to be disposed in the Conservation Park Zone adjacent to the Tin Can Bay township
 - changing zoning or develop new management provisions to allow beach scraping at vehicle beach access points on K'gari (Fraser Island)
 - improving management of moorings, including converting all existing buoy moorings in Tin Can Bay to environmentally-friendly moorings and requiring all new moorings to be of an environmentally friendly design.

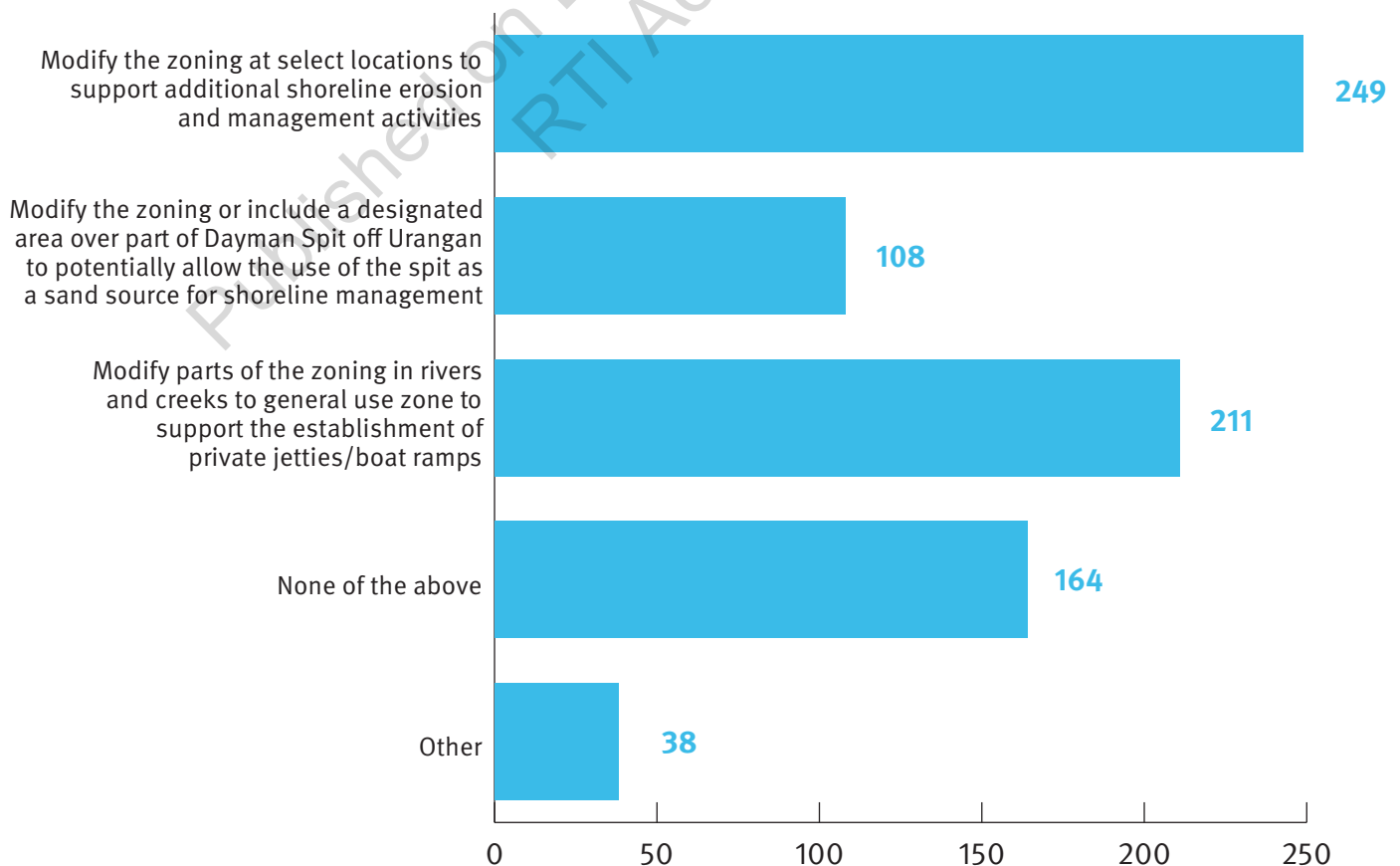


Figure 15: Survey responses on options for managing various coastal development issues

Marine Park management

- Fifty-four percent (54%) of survey respondents indicated that the marine park was not adequately protected, while still allowing a range of activities to be undertaken (Figure 16).
- Respondents requested a range of other marine park management changes including:
 - improving signage of green zone boundaries
 - increasing compliance activities in the marine park especially the Go Slow Areas, fishing in green zones, 4WD use in intertidal areas and designated shorebird roosting and feeding areas
 - increasing the overall size of the marine park by extending the boundary north and/or south as well as including the Barubbra Island area in the Port of Bundaberg to protect areas of high conservation value and species migration corridors
 - increasing partnership and involvement of First Nations peoples and Indigenous rangers in research, education and compliance activities in the marine park.

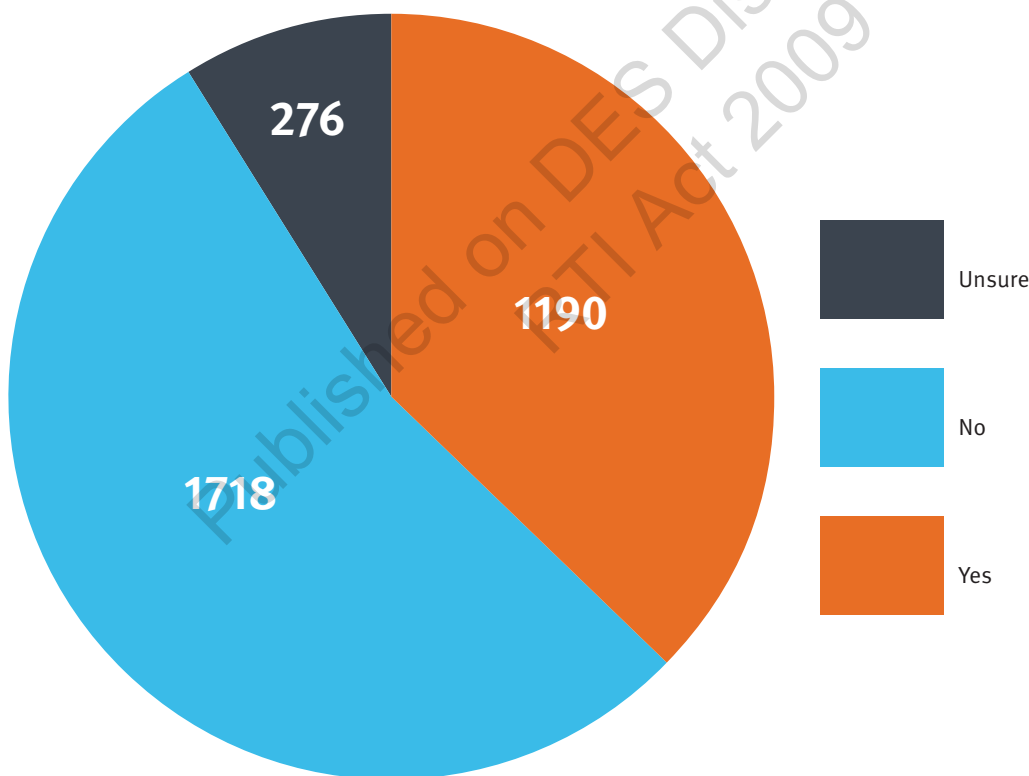


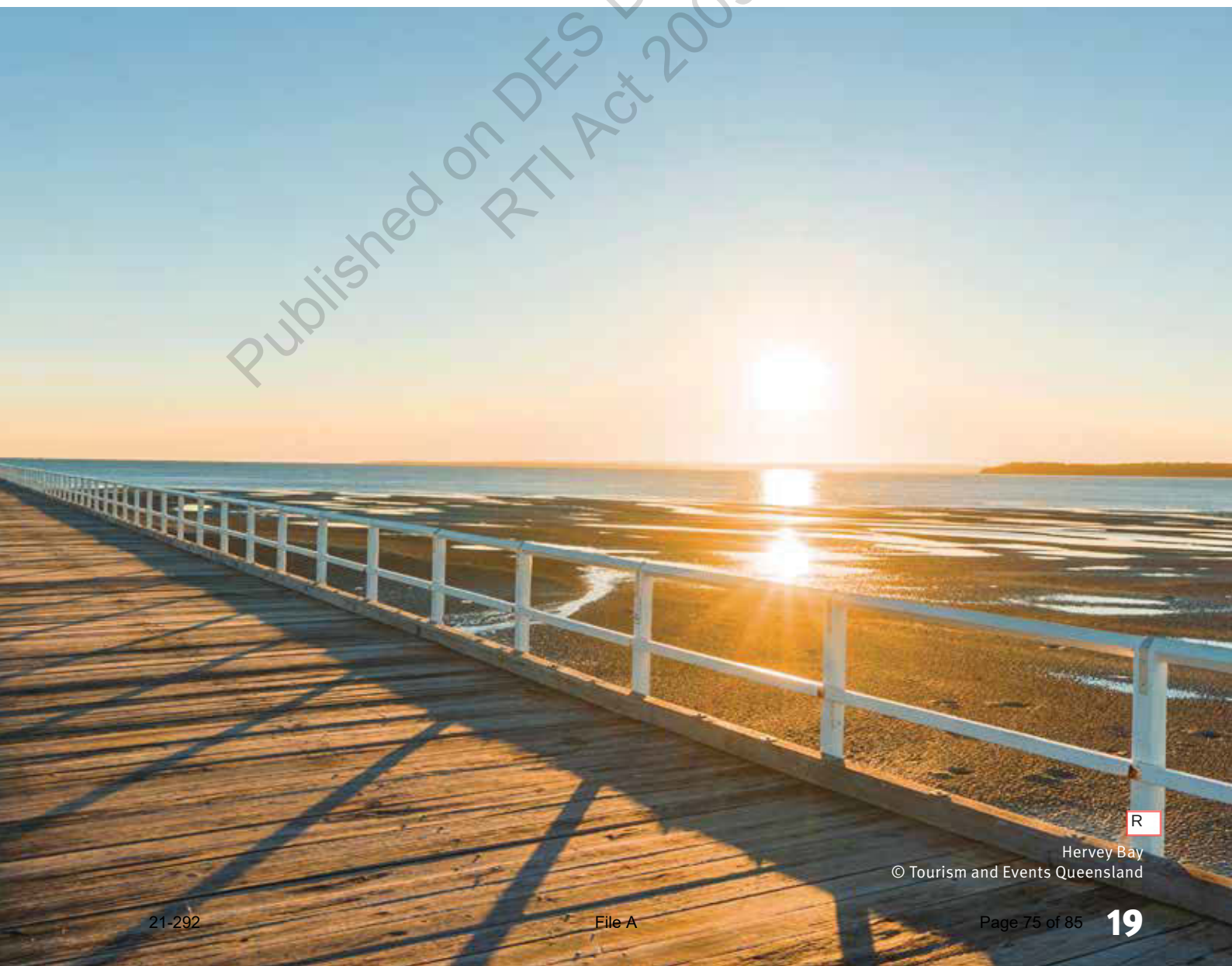
Figure 16: Survey responses on adequacy of marine park protection



Non-marine park management issues

Other feedback concerned matters that cannot be specifically addressed in a marine park zoning plan or are the responsibility of another management agency:

- Reduce the recreational possession limits of certain species including crabs, barramundi and prawns.
- Amend the size limits for certain fish species.
- Prohibit certain fishing gear types such as lightweight crab pots.
- Prohibit spearfishing in certain locations.
- Limit access to the marine park to local commercial fishers only.
- Restrict the number of pots that can be used by commercial and recreational crab fishers.
- Introduce a licence for recreational fishers.
- Ban catch and release fishing.
- Restrict the number of recreational fishers.
- Increase compliance of fisheries regulations.
- Modification of river systems and water flow by weirs and barrages have reduced fish stocks.
- Manage catchment activities that have an impact on the water quality of the marine park.
- Improve recreational fishing access with more boat ramps.
- Introduce designated no-go or no-approach areas where humpback whales are nurturing new calves.



Next steps

Stakeholder feedback will be used together with advice from First Nations people who have sea Country in the marine park and the Great Sandy Marine Park Scientific Reference Group to guide the development of a draft revised zoning plan. The plan will also be informed by best practice marine park management principles.

More information

Find out more about the review of the Zoning Plan for Great Sandy Marine Park and process on the Department of Environment and Science website:

<https://parks.des.qld.gov.au/parks/great-sandy-marine/>

R

Organisations that made a submission as part of GSMP Zoning Plan Review Consultation

- Australian Fishing Trade Association
- Australian Hovercraft Federation Inc
- Australian Marine Conservation Society
- Australian Whale Conservation Society
- Baffle Creek Family Fishing Festival
- Baffle Creek North Side Committee
- Baffle Creek South Side Committee
- Barubbra Island Community Progress Association
- Birds QLD
- Bundaberg and District Urban Landcare Assoc. Inc
- Bundaberg Regional Council
- Bundaberg Skindivers
- Burnett Local Marine Advisory Committee
- Burnett Mary Regional Group
- Butchulla Aboriginal Corporation
- CAREFISH—CAirns REcreational Fishing Industry Stake Holders (*)
- Cooloola Coastcare Inc (*)
- East Coast Crab Fishers Network
- Fraser Coast Fishing Alliance Incorporated
- Fraser Coast Regional Council
- Fraser Coast Tourism and Events
- Fraser Island Defenders Organisation
- Fraser Island World Heritage Area Community and Scientific Advisory Committees
- Friends of the Burrum River System Group (*)
- Gidarjil Development Corporation
- Gladstone Conservation Council
- Gladstone Regional Council
- Hervey Bay Game Fishing Club
- Hervey Bay Seafood Festival Association
- Hervey Bay Seafood Inc
- Hervey Bay Stand Up Paddle Group
- Kekoa (*)
- Mary River Catchment Co-ordinating Committee
- Poona Community Progress Association
- Port Curtis Coral Coast Traditional Owners TUMRA Committee
- Protect the Bush Alliance (*)
- Provision Reef Inc.
- Queensland Seafood Industry Association
- Queensland Sporting Hovercraft Club
- Queensland Wader Study Group (*)
- River Heads Fishing Club (*)
- River Heads Progress Association
- Sea Turtle Foundation (*)
- Sunfish QLD (*)
- Sydney Fish Market
- Wide Bay Burnett Environment Council (*)
- Wildlife Preservation Society of QLD—Fraser Coast Branch
- Wildlife Preservation Society of QLD (*)
- Winfield Conservation Inc
- World Wildlife Fund (*)

The following organisations and businesses in addition to those marked with (*) above provided a joint submission:

- Birdlife Southern Queensland
- Butchulla Men's Business Aboriginal Association
- Caravanning Queensland
- Fraser Guided Fishing
- Noosa Parks Association
- Queensland Conservation
- Queensland Recreational Fishing Network
- The Oceania Project
- Wilderness Society





Great Sandy Marine Park Zoning Plan Review

Stakeholder and community feedback

Background

The Department of Environment and Science (DES) is currently undertaking a comprehensive review of the Great Sandy Marine Park Zoning Plan (the Zoning Plan). As part of the review process stakeholder groups and the public have provided feedback on the existing Zoning Plan and have proposed a wide range of changes to the marine park's management.

Formal public consultation has occurred at two key stages in the review process to date:

- during the statutory remake of the Great Sandy Marine Park (GSMP) Zoning Plan in 2017, and
- through the release of the *Great Sandy Marine Park Discussion Paper – Zoning plan opportunities* (the Discussion Paper) in January 2019.

Feedback in response to this consultation has been received in various forms including:

- written submissions
- responses to the survey that accompanied the Discussion Paper
- phone conversations
- correspondence in the form of letters and emails
- meetings
- petitions.

Key feedback

In general, feedback regarding the future management of Great Sandy Marine Park indicated that:

- Improvements to the Zoning Plan are required to better protect and conserve, the habitats and species, especially threatened species, within the marine park from current and emerging threats.
- Expansion of the Marine National Park (green) Zone network is well regarded as a key method for delivering improved marine park conservation outcomes. However, this view is not universally held and some stakeholders consider large green zones to be a significant threat to their current use of the park.
- The current management which allows commercial net fishing to be conducted in the Conservation Park Zone is highly contested in the Great Sandy Strait, and to a lesser but still significant extent Baffle Creek, Elliott River, and Burrum River (the waterways within the designated Great Sandy Area).
- Protection and support for First Nations people's rights, cultural values and aspirations for country need to be better integrated into the marine park management.
- Nature-based and recreational fishing tourism are growing drawcards and, if properly protected, can increase both ecological and economic value of the marine park to the region.
- Works, necessary for the provision and protection of public infrastructure, need to be better accommodated by the marine park management.

R

First Nations people and stakeholders

Collaboration with First Nations people in the region is a priority in the development of a draft revised zoning plan for the marine park. Aspirations and interests of First Nations people have ranged from expressions about additional provisions to protect and support the management of cultural values, improved mapping of cultural heritage resources through to increased partnership and involvement in research, education and compliance activities.

In addition to collaboration with First Nations peoples, liaison with other government departments and feedback from members of the public, the following organisations have made submissions as part of the GSMP zoning plan review consultation:

- Australian Fishing Trade Association
- Australian Hovercraft Federation Inc
- Australian Marine Conservation Society
- Australian Whale Conservation Society
- Baffle Creek Family Fishing Festival
- Baffle Creek North Side Committee
- Baffle Creek South Side Committee
- Barubbra Island Community Progress Association
- Birdlife Southern Queensland
- Birds QLD
- Bundaberg and District Urban Landcare Assoc. Inc
- Bundaberg Regional Council
- Bundaberg Skindivers
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- Poona Community Progress Association
- Port Curtis Coral Coast Traditional Owners TUMRA Committee
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- Sea Turtle Foundation
- Sunfish QLD
- Sydney Fish Market
- The Oceania Project
- Wide Bay Burnett Environment Council
- Wilderness Society
- Wildlife Preservation Society of QLD – Fraser Coast Branch
- Wildlife Preservation Society of QLD
- Winfield Conservation Inc.
- World Wildlife Fund

Feedback summary

The community feedback comprised a range of views including support for recreational fishing-based lifestyles, the provision of fresh seafood by local commercial fishers, and better protection of nationally and internationally important populations of threatened species. Submissions also indicated that amendments to the zoning plan that support both fishing and species protection will generate future tourism opportunities and make a valuable contribution to the region's economy.

Protection of threatened species and unique habitat types

The marine park supports a diversity of habitat types and species, several of which are internationally significant. A number of threatened species are also present within the marine park for all or part of their lifecycle. There is general support to include management arrangements that assist in the protection of these species. Feedback received on specific species is outlined below.

Humpback whales

Hervey Bay is an internationally recognised resting location for several whale species on their return migration to Antarctica. Increased protection for humpback whales while they are in the marine park was promoted by a small number of submissions.

These submissions suggested the need to:

- Introduce a Go Slow Area in Platypus Bay to protect whales from boat strike during their annual migration.
- Safeguard humpback whale habitat in Hervey Bay in recognition of the importance of the area to the reproductive success of the species.
- Prohibit crabbing in Platypus Bay during whale season.
- Better manage, and monitor, swim-with-whale programs and general whale watching tourism.
- Introduce a designated “no-go” or “no-approach” areas where humpback whales are nurturing new calves.

Grey nurse shark

There were mixed views on whether there should be increased protection for grey nurse sharks in the marine park. Wolf Rock, near Double Island Point provides nationally significant habitat for critically endangered grey nurse sharks and is the only known gestation site and most northern known aggregation site for this species on the east Australian coast.

Key feedback points and suggestions:

- A small number of submissions suggested increasing the size of the existing green zone around Wolf Rock to better protect grey nurse sharks from the impacts of fishing at this significant aggregation site.
- One submission suggested expanding the current buffer zone around Wolf Rock to increase protection for grey nurse sharks while allowing recreational fishers to troll for pelagic fish species.
- A small number of submissions indicated that expanding the green zone around Wolf Rock is likely to impact commercial line fishers who operate off Double Island Point.
- Some support for restricting scuba diving at Wolf Rock to marine park permit holders.

Migratory shorebirds

The marine park is utilised by thousands of resident and international migratory shorebirds (five species of which occur in internationally significant numbers) that are protected by various International Conventions of which Australia is a signatory. The Great Sandy Strait is a Ramsar site and recognised as the second most important region for shorebirds in Queensland.

Key feedback points and suggestions:

- General support for introducing park-wide rules to protect shorebirds and their habitat from intentional disturbance.
- Several submissions also suggested introducing seasonal access restrictions at key high tide migratory shorebird roost sites.

Turtles and dugong

Six of the seven species of marine sea turtles that occur within Australian waters are found in the marine park. Internationally recognised Mon Repos beach, near Bundaberg, supports the largest concentration of nesting turtles on the eastern Australian mainland and the largest loggerhead turtle nesting population in the South Pacific Ocean.

Key feedback points and suggestions:

- Many submissions indicated that current green zones, Conservation Park Zones and Go Slow Areas are inadequate to protect turtles and dugong based on the improved knowledge of species distribution and that there should be more Go Slow Areas in the marine park to protect turtles and dugong from the risk of boat strike.
- A small number of submissions indicated that Go Slow Areas affect commercial fishing operations and suggested that commercial fishers should be exempt if operating under an agreed Code of Practice.
- Some submissions proposed increasing the size of the seasonal Go Slow Area at the northern end of K'gari (Fraser Island) to improve protection of nesting turtles, while others sought the removal of this Go Slow Area based on its potential safety impacts on boaters returning from offshore waters during adverse weather conditions.
- The introduction of beach access restrictions and a Go Slow Area for vessels to protect nesting turtles on Moore Park Beach, similar to Mon Repos, was proposed in a small number of submissions.
- A change in zoning to prohibit trawling in the vicinity of Moore Park Beach to protect nesting turtles and hatchlings was also suggested.
- Several submissions supported other potential changes to existing zoning plan rules to improve protection for turtles at Mon Repos including the establishment of a green zone and extending the seasonal commencement date of the designated Mon Repos Area to allow for changes in the nesting pattern of turtles at this location.
- The introduction of restrictions to prevent domestic animals and vehicles from accessing the beach between Littabella Creek and Baffle Creek to protect nesting turtles, was also raised in some submissions.

Coral reefs

Great Sandy Marine Park is home to a diversity of tropical, subtropical and temperate species of soft and hard corals, some of which are endemic or rare to the region. Hervey Bay coral reefs are estimated to be 6,500 years old and are the approximate southern limit of healthy fringing coral reef formations along the east coast of Australia.

Key feedback points and suggestions:

- General support for protecting more areas of coral and seagrass habitat within the marine park.
- There are mixed views about introducing no anchoring areas rather than green zones to protect coral at locations such as Gatakers Bay, Point Vernon and the reefs near Pialba and Scarness.
- An exemption for commercial fishers, especially those involved in the marine aquarium fish fishery from any anchoring restrictions, was suggested.
- There is some support for improving protection of Four Mile Reef. Several scientists have indicated that it is the only example in the marine park of a coral reef with a vertical and continuous calcareous structure that also supports a unique coral assemblage. Conversely there is opposition to introducing greater protection at Four Mile Reef, with some stating that it is a popular recreational fishing location and a marine aquarium fish fishery location.

Marine National Park (green) Zones

General feedback supports increasing the area of the marine park included in highly protected Marine National Park (green) Zones, with at least 10% of the marine park in green zones.

Key feedback points and suggestions:

- Ensure that a proportion of each habitat type found in the marine park is protected in a green zone.
- Apply best practice reserve design principles including appropriate size and spacing, replication, and placement to promote ecosystem connectivity.
- Provide refugia for species being impacted by climate change by increasing the area of green zones.
- Create new green zones at various locations in the marine park, including around the ex-HMAS Tobruk, Seary's Creek and along the foreshore between Moon Point and Black Creek on K'gari (Fraser Island).
- While there is support for an increase in green zones, other submissions suggest a reduction in the area of

green zones to allow greater access for recreational fishers.

- Strong opposition to establishing a green zone in Baffle Creek because of potential impacts on tourism and real estate values in the area.

Designated Great Sandy Area

The designated Great Sandy Area which allows (as an overlay) commercial net fishing in a Conservation Park Zone, attracted a large amount of feedback and is particularly contentious. A clear divide exists between conservation and recreational fishing interests and the commercial fishing industry.

Key feedback points and suggestions:

- Many submissions argued that the underlying Conservation Park Zone should be retained, but that the Great Sandy Area rules should be changed or removed for the following reasons:
 - Better recognition of the Great Sandy Strait as an internationally important Ramsar listed wetland adjacent to the K'gari (Fraser Island) World Heritage Area.
 - It will better protect wildlife, including threatened species, from entanglement with fishing nets.
 - It will promote tourism and recreational fishing experiences by increasing fish stocks.
 - The economic benefits generated by recreational fishing and tourism would outweigh the existing value of the commercial net fishery.
 - Commercial netting does not align with the objectives of the underlying Conservation Park Zone.
- Conversely, other submissions argued for not changing the current zoning plan provisions (designated area and non-conforming uses) which allow the continuation of the existing commercial net, line, crab and some trawl fisheries within the waterways of the Great Sandy Area, for the following reasons:
 - It provides fresh local seafood to the general public who do not fish.
 - It increases the value of fishing businesses to the regional economy through direct employment.
 - It creates business activity which in turn supports local industries and other businesses.
 - It recognises the long history of stewardship and sustainable fishing within the waterways and the important contribution that commercial fishing delivers to the cultural and social fabric of the region.

Commercial fishing (general)

The Great Sandy Marine Park is a multiple use marine park and as such it supports a range of diverse activities including a number of commercial fisheries. A range of views have been expressed regarding the continuation of this activity within the marine park.

Key feedback points and suggestions:

- Introduce additional restrictions on commercial bait netting in Conservation Park Zones.
- Remove commercial netting from everywhere in the marine park.
- Remove trawling and commercial crabbing from everywhere in the marine park.
- Remove commercial fishing activities such as trawling, netting and crabbing from various locations in the marine park.
- Commercial fishing operators seek to maintain a strong local commercial fishing industry.
- Only allow local and/or long-term commercial fishers to operate in the marine park.
- Ensure a structural adjustment package is provided for impacted commercial fishers.
- The majority of submissions support the phasing out of the following non-conforming (*) commercial fishing activities in the marine park:
 - beam trawling in the Mary River
 - coral collecting in the vicinity of Woody Island
 - marine aquarium fish fishery in the Little Woody Island green zone
 - crab fishing in the Great Sandy Strait, Baffle Creek, Elliott River and Burrum River.
- A small number of written submissions sought to maintain the non-conforming use provisions, in particular the continued reliance of the commercial marine aquarium fish fishery on the green zone at Little Woody Island for commercial export markets.

() Non-conforming use provisions allow for the continuation of an activity, in areas where it would otherwise be prohibited by zoning*

Local Government

Local government plays a key role in coastal management activities within the marine park such as undertaking protection works to limit impacts from coastal erosion on property and infrastructure. Much of the feedback from local government focuses on the need for changes to the zoning plan to allow coastal protection works to be undertaken in the marine park.

Key feedback points and suggestions:

- Amend the zoning in the vicinity of Dayman Spit so sand can be used as a source of nourishment material for Hervey Bay beaches.
- Change zoning or develop new management provisions to allow beach scraping for maintenance of vehicle beach access points on K'gari (Fraser Island).
- Change the zoning at locations adjacent to developed foreshores to allow erosion management for climate change resilience works by local government.

Other issues

Feedback from stakeholders and the community has also been provided on a range of other topics and issues.

Key feedback points and suggestions:

- Increase the overall size of the marine park by extending the boundary north and/or south as well as including the Barubbra Island area in the Port of Bundaberg to protect areas of high conservation value and species migration corridors.
- Remove the permit requirement for vessels such as hovercraft to operate in the marine park
- Establish more artificial reefs to promote recreational fishing
- Improve management of moorings, including converting all existing buoy moorings in Tin Can Bay to environmentally-friendly moorings and requiring all new moorings to be of an environmentally friendly design.
- Regulate four wheel drive vehicle use in intertidal areas and designated shorebird roosting and feeding areas.
- A range of views were expressed on private structures such as jetties and boat ramps, including streamlining the authorisation process for private structures, prohibiting private structures, minimising the number of private jetties and boat ramps, and adjusting the zoning in places to allow for particular structures.
- A range of views were expressed on dredging within the marine park, from prohibiting the activity to proposals for dredging in particular locations for specific purposes.
- Opposing views on whether aquaculture should be allowed in the marine park.

Non zoning plan issues

Suggestions have also been received on issues that cannot be specifically addressed in a marine park zoning plan or are the responsibility of another management agency.

Key suggestions:

- Reduce the recreational possession limits of certain species including crabs, barramundi and prawns.
- Amend the size limits for certain fish species.
- Prohibit certain fishing gear types such as lightweight crab pots.
- Prohibit spearfishing in certain locations.
- Limit access to the marine park to local commercial fishers only.
- Restrict the number of pots that can be used by commercial and recreational crab fishers.
- Introduce a licence for recreational fishers.
- Ban catch and release fishing.
- Restrict the number of recreational fishers.
- Manage catchment activities that have an impact on the water quality of the marine park.

- Improve recreational fishing access with more boat ramps.
- Improve management of river systems that have been modified by weirs and barrages to reduce flow which has resulted in reduced fish stocks.

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