Conflict Islands Turtle Conservation Project: 2018/19 Nesting Season Report

Turtle Tagging and Monitoring at the Conflict Islands, Milne Bay Province

November 2018- March 2019

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Introduction

Papua New Guinea (PNG) is one of the world's richest natural resource holders, with 7% of the world's biodiversity (Faith et al 2000a, 2000b). The people of PNG rely heavily on the natural resources to provide them with their cultural, comestible and economic persistence. However, PNG is also a developing country, with a large reliance of international input and assistance for their land-based services, including mineral extraction, palm plantations, schools and hospitals, with little or no national benefit (Huber et al 2001, Basnyat 2008). The surrounding marine ecosystem is rich with marine life, housing coral reefs, endemic and endangered species (IUCN Red List). It is estimated that 250 000- 500 000 PNG Nationals rely on the surrounding marine ecosystem to sustain their communities, especially in the Milne Bay Province, where there are 276,000 people living with around 160 isolated island communities who have very minimal access to mainland services (FCP PNG 2002). Therefore, it is no surprise that this developing region has little to no protection and scientific management of it's habitats and inhabitants.

The Department of Environment and Conservation (DEC) was created in 1985 to "ensure natural and physical resources are managed to sustain environmental quality and human well-being" (DEC PNG 2009). DEC has administered key legislations, including:

- Environmental Planning Act 1978
- Environmental Contaminants Act 1978
- Conservation Areas Act 1978
- National Parks Act 1982
- International Trade (Fauna & Flora) Act 1979
- Fauna (Protection and Control) Act 1966
- Crocodile Trade (Protection) Act 1974
- Water Resources Act 1982

Under these legislations, conservation is still limited in PNG. On land, only 3% of the rich forests are protected, with four national parks, three provincial parks and 27 wildlife management areas. Customary ownership has created difficulty in expansion of these protected areas, as 96% of the land is still held this way, however the DEC continues to explore workable models for conservation management under a "conservation system" (DEC PNG 2009). Marine habitats have only recently become a conservation priority for the Government, as per a report in 2009. Marine conservation management has been lightly established in the Hiri East zone management area, where there are efforts to rehabilitate marine and coastal habitats, however much of the focus of conservation is found within the crocodile trade and the export of wild flora and fauna, most notably species of crocodiles and butterflies. The need for marine conservation and awareness of sustainable harvesting in PNG has increased with international demand on their resources. For example, the tuna fishery in PNG makes up 11% of the global catch (500 000t), but there was no adequate management for the illegal, unreported and unregulated fishing of these species until 2014, where international authorities had to threaten trade sanctions on fisheries imports (www.politico.eu…). Although there are no real numbers for how many marine species are taken illegally from PNG waters, beche-de-mer, rock lobster, mud crabs, tuna, trevally, sharks and turtles are some of the target species that are sold on the black market all around the world. The added pressure of anthropogenic climate change, including more frequent and harsher weather patterns, sea-level rise, sea temperature and ocean acidification continues threaten impoverished, isolated communities within the Milne Bay province who rely on harvesting local marine flora and fauna to survive.

Historically, isolated communities have relied on harvesting marine turtles for their food, tools and jewellery within tribes. Traditional harvesting has cultural conservation, including a social hierarchy that allows only few members and their families within tribes to hunt specific animals, including marine turtles. Historic regulations and laws has been effective in the past, however these traditional customs are not being abided by since Western influence arrived in PNG. The carapace of Hawksbill turtles (*Eretmochelys imbricata*) is a highly sought-after material used in the fashion, medicinal and ornamental industry contributing to the USD$24 billion made in the illegal wildlife trade. Additionally, population growth in PNG has increased around ~2% each year since 1950 (http://www.worldometers.info), which has put further pressure on turtle populations due to the increased demand for their meat and eggs for powder, oil and fat. Hence, very little data or knowledge on marine turtle populations, species diversity and abundance has been collected around PNG. Conflict Islands Conservation Initiative (CICI) aims to create a baseline dataset of Green turtles (*Chelonia mydas*) and Hawksbill turtles (*E. imbricata*) to establish the population around the Conflict Group in the Milne Bay province. This will give an indication of marine turtle populations in this region and whether these species needs further local management to maintain populations for sustainable harvesting in isolated communities who rely on this resource to survive.

This report focuses on the continuation of the nesting female turtle tagging and monitoring program on the Conflict Islands (CI), established in 2017, and what the data collected is telling us thus far. This report follows on from the Turtle Season Summary Report of 2017-2018, where nesting Green and Hawksbill turtles were monitored and tagged through the months of November to February. The aims of this long-term monitoring program are to establish information on the nesting populations of endangered green turtles (*C. mydas*) and critically endangered Hawksbill turtles (*E. imbricata*). The Conflict Islands provide suitable nesting habitats for these turtles, which are privately owned and protected under the Papua New Guinea *Land Act 1996*. Throughout the nesting season (November - March each year), monitoring these populations through flipper tagging, satellite tracking and genetic sampling of individual Green and Hawksbill turtles allows CICI to establish the population density utilising these habitats and how fecund they are. Subsequent yearly comparisons of Green and Hawksbill turtle populations around CI will be undertaken to establish trends in populations, genetic connectivity and identify threats around the Milne Bay province. This project also aims to create effective awareness within the surrounding island communities in turtle conservation, training of PNG Nationals as turtle rangers and promoting environmental sustainability through engagement in community awareness days. Overall, CICI will use this accumulated data to determine the effectiveness of ongoing conservation efforts in this region.

Methods

Sites

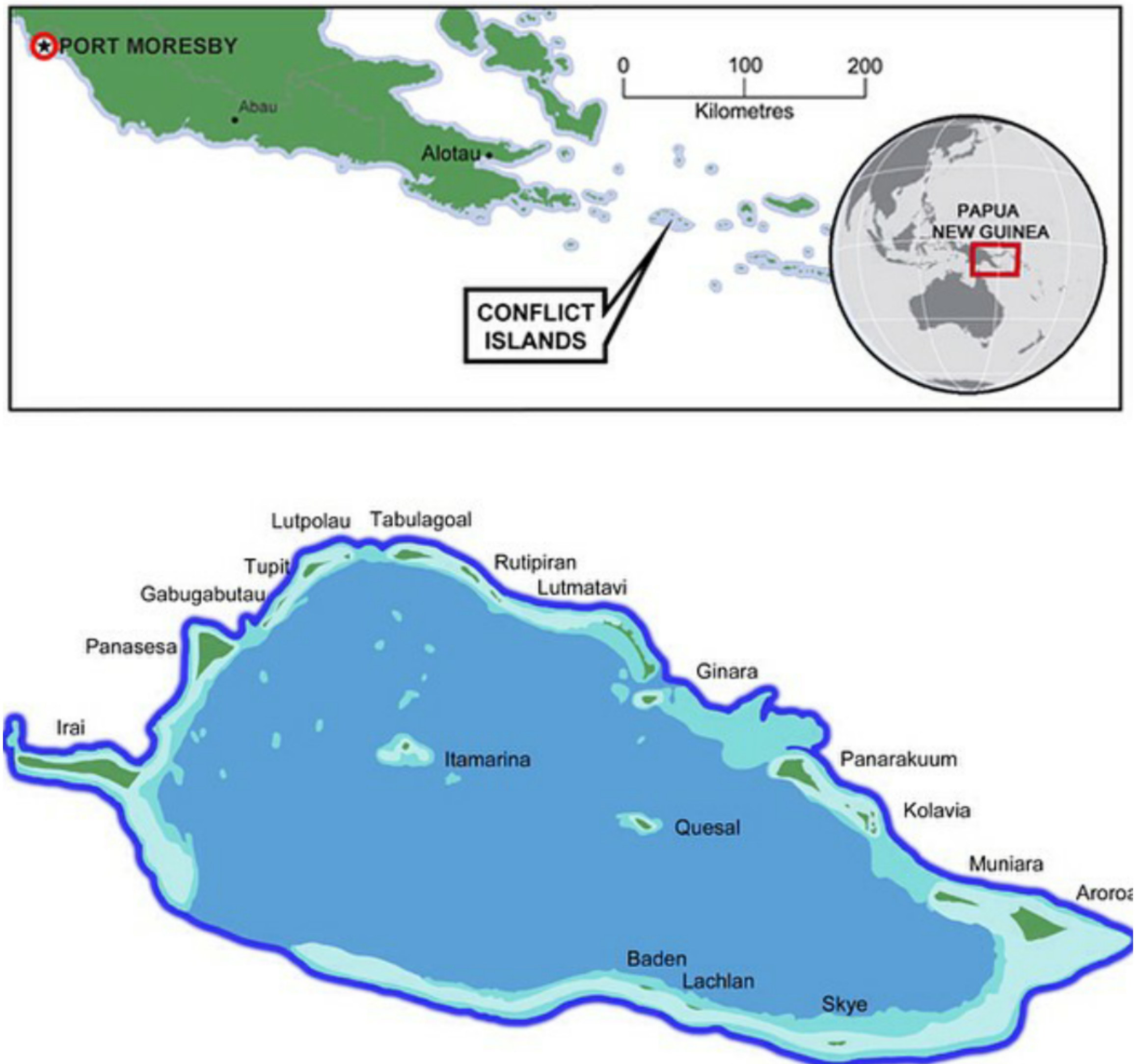

Figure 1: Sampling sites at Conflict Group: Irai, Panasesa, Gabugabutau, Tupit (Tobiki), Tabulagoal, Panaboal, Ginara, Panarakuum, Kolavia, Muniara, Auoroa and the Reef Islands (Baden, Lachlan and Skye)

Tagging

The tagging method was adapted from standard SPREP tagging instructions (Geermans, 1993) sections 2 (2.2) and 3 (3.1, 3.2and 3.3). Female turtles were tagged on nightly patrols during the months of October 2018- February 2019. The patrols started at 6pm and finished at low tide, usually around 12am. The turtles were tagged with standard self-locking titanium tags. The tags belong to the Conflict Islands Conservation Initiative; tag series IGS0001-IGS1000. Recorded data included:

- Species
- Date/ Time of laying
- GPS location of nest
- Nest Habitat
- Number of eggs laid (if possible)
- Nest fails
- Reason for Nest fail

When the female I returning to the ocean, she is flipper tagged on the trailing edge of her front left or right flipper on Pad L1 (closest to the body) if possible, otherwise subsequent Pads, L2 or L3 will be tagged. The tag number will be recorded as well as any injuries or previous tags.

Egg Collection & Relocation/ Hatchlings

Eggs are only relocated if they are at high-risk of mortality; this includes poachers nearby, predators nearby or the female has dug her egg-chamber below the high-tide line. As the female starts laying her eggs into her egg-chamber, she will go into a trance-like state, this is when patrollers will put a pillow case at the base of her cloaca to cushion the eggs as they come out. Eggs are then counted and put into a zip-lock sandwich bag and the air is removed to mimic hypoxia during relocation, which stunts development of the embryo until they are reburied (Williamson et al 2017, Kam 1993, Kennett et al 1993). The eggs are then transported to the Hatchery on Panasesa Island within **two hours** of collection to decrease mortality. A new nest is dug in the hatchery, to the same depth and width as the natural nest. Cover the nest in wet sand first, followed by drier sand. The species, number of eggs and estimated hatching date are all recorded.

Marine turtles undergo TSD (Standora & Spotila 1985) consequently the new egg chambers in the hatcheries were dug with wet cooler sand at the bottom and dry, warmer sand at the top to mimic their natural nests. There are four hatcheries in total on Panasesa. Two located near the Airstrip, one with natural shade and one with a roof, and two located towards Due South Beach, one with no shade and one with a roof. Hatchlings that emerged were morphologically measured (Weight (g), CCL (mm), CCW (mm) and body depth (mm). They underwent a "fitness test" of being able to right themselves from their carapace 3 times. The hatchlings that could do this and had no morphological dysfunction were released from the beach closest to their hatchery, while others (20% weakest from nest) were brought to the Turtle Nursery for further husbandry and observation. Melissa Staines, honours student of the University of Queensland, conducted hatchling success data and we will receive the results of this conducted study once she has finished her Honours report.

Turtle Rodeo

"Rodeos" were conducted during the months of October 2018 – February 2019. Juvenile and male Hawksbill and Green turtles were captured when encountered during systematic searches of the various reef and lagoonal habitats around the Conflict Islands. Turtles were captured by day using the turtle rodeo and beach jump capture methods (*See* Limpus 1992). Following their capture, turtles were flipper tagged at their trailing edge front flippers and morphological data and genetic sampling were collected, including CCL(cm), CW(cm), Age class, Gender and any injuries recorded. They were released from the island or boat usually within one hour of being captured.

Genetic Sampling

Tissue samples were routinely collected from Hawksbill and Green turtles while nesting or juvenile green turtles captured in feeding areas for genetic analysis. A scalpel was used to incise a small section of tissue (< 0.25 cm^3) from the trailing edge of a rear flipper. Samples were then placed in a vial containing 100% ethanol. These samples have been refrigerated in -4°C until there is enough samples to analyse them in Australia, partnering with James Cook University (Dr Ellen Ariel, green samples) and the University of Sunshine Coast (Christine Hof, hawksbill samples).

Results

Nesting Females

During the 2018-19 turtle-nesting season at Conflict Islands, a total of 226 nesting female turtles were tagged. Since CICI established in 2017, 606 Green and 126 Hawksbill turtles were tagged during nesting or through Rodeo. CICI has contributed a total of 732 identification tags on turtles around the CI and Milne Bay Province. Comparing the two seasons, nesting Green turtles tagged in 2018-19 season dropped by 18.5%. However, nesting Hawksbill turtles increased by 18.49% (Figure 1). This could be due to the number of volunteers and patrols we had during each season; 2017 had a higher number in interns and volunteers, therefore the effort for patrolling beaches and tagging turtles could be spread out further to the 14 nesting islands over longer periods. Inters and volunteers could have come across more Hawksbills compared to last season by chance. However, it is positive that CICI are finding more critically endangered Hawksbill turtles utilising the protected and patrolled beaches of CI.

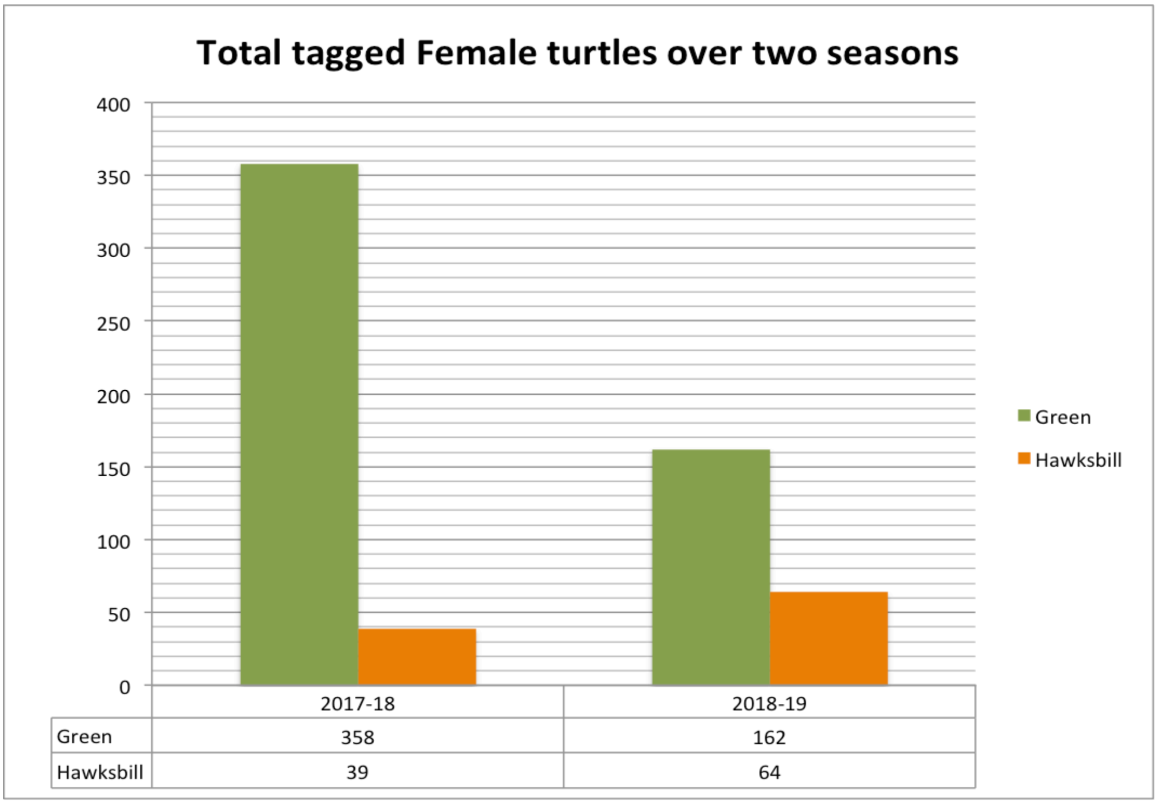

Figure 1. Total nesting females tagged over 2017-19.

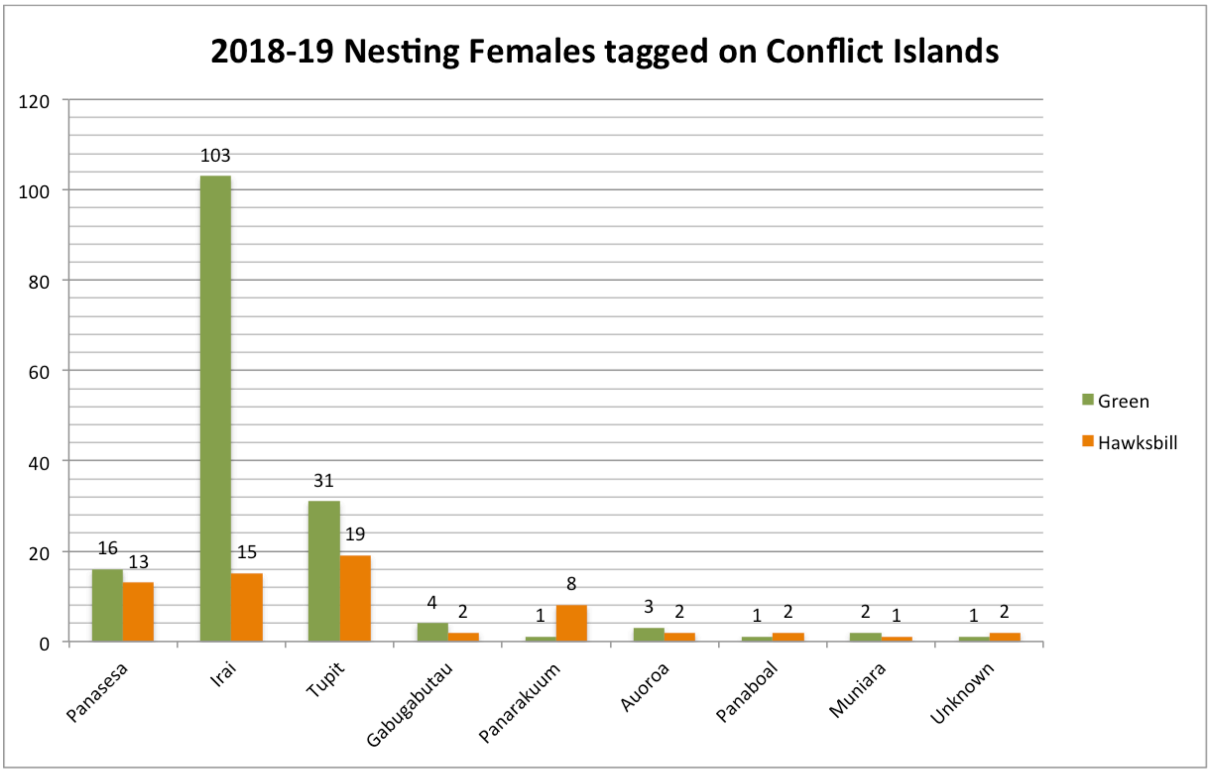

Figure 2. CI islands where nesting females were tagged in 2018-19.

During the 2018-19 nesting season, eight known islands of interest were patrolled, with "unknown" category for missing data (Figure 2). The main islands that were patrolled were Panasesa, Irai and Tupit, as these are the closest islands together and the safest to patrol if experiencing bad weather. Female green turtles were encountered the most on Irai (63.58%), followed by Tupit (11.73%) and Panasesa (9.88%). The other islands patrolled made up only 7.41% total. Hawksbill turtles were encountered the most on Tupit (29.69%), followed by Irai (23.44%) and Panasesa (20.31%). The other islands made up a total of 26.56%, which tell us that hawksbills could prefer other islands such as Panarakuum (12.5%), than the three most-patrolled islands. It should be noted that this data does not represent the most popular islands for turtle nesting, as the patrols were focused mainly on the three islands that were close and convenient with weather, hence they have the most encounters. When comparing the 2018-19 patrol data to the 2017-18 patrol data (Figure 3), it is noticeable that the previous nesting season had more opportunity to patrol further around the atoll. Irai, Panasesa and Tupit were still where most of the greens and hawksbills were found, although higher encounters with greens were also found at Panarakuum (7.54%), Auoroa (8.38%) and Tabunagaol (13.13%). Hawksbills only had 39 encounters during the 2017-18 season, however Panarakuum and Kolavia (both at 15.38%), seem to have had higher encounters with this species.

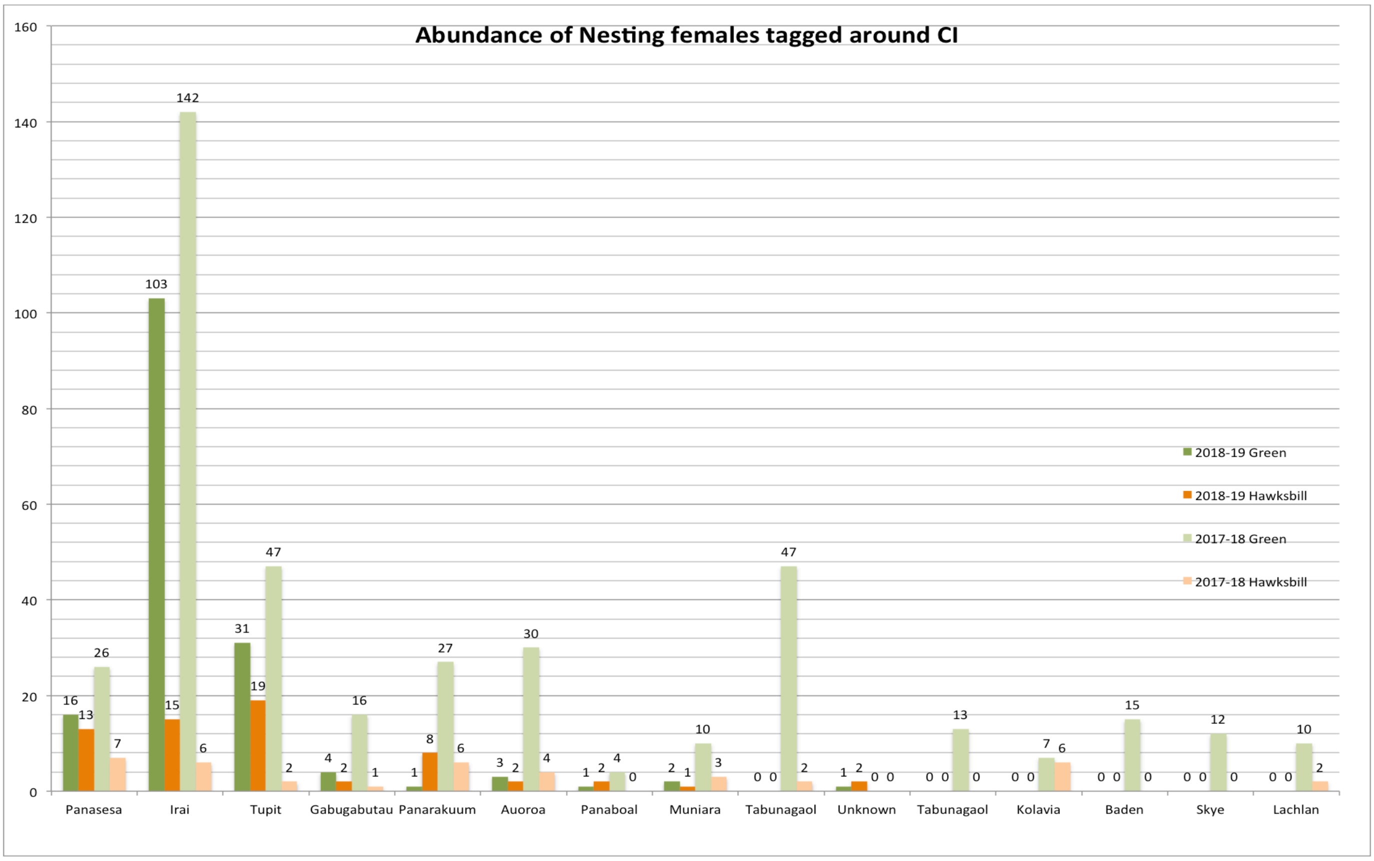

Figure 3. Overall encounters of nesting turtles on Conflict Islands from 2017-2019.

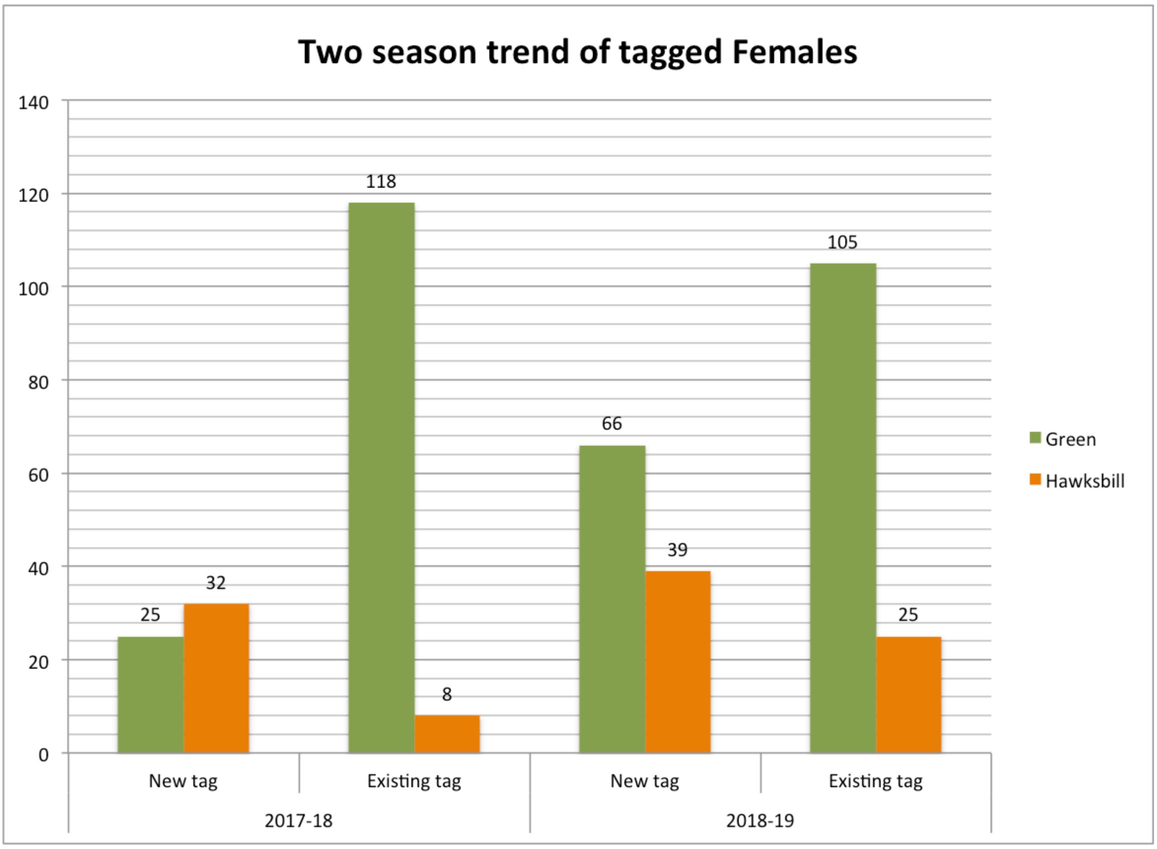

Figure 4. Female turtles with new tags vs. existing tags during consecutive nesting seasons.

Remigrant nesting females included nine tags from SPREP's Samoa turtle tagging program and two from DEHP's branch in Queensland, Australia. The hawksbill turtles that were tagged previously in Queensland continue to highlight the connectivity between foraging and nesting grounds in the GBR, Australia, and the South pacific Islands of Samoa and PNG. There was a 13.7% increase in primary female hawkbills caught in 2018-19 season and a 45.1% increase in primary female greens. Whereas there was a 51.5% increase in remigrant hawksbills and a 5.8% decrease in remigrant greens (Figure 4). From the data, remigrant female greens and hawksbills are coming back annually to nest, which is not common in their life cycle and is very important for CICI's goals in conservation and the need to continue to tag and record remigrant and primary females utilising CI habitats.

Over the 2018-19 nesting season, the highest abundance of female green turtles was encountered in January (51.85%), followed by December (24.69%), November (12.35%) and February (10.49%) (Figure 5). Hawksbills were encountered most is December (42.18%), followed by January (29.69%) and November (23.44%). Compared to last season's turtle report (*See* EOS CI Turtle report 2017-18, N Robinson), green turtles peak nesting on CI was found in December and hawksbills in January, although the data size (n) was smaller for hawksbills when compared to this season (See Figure 1). From these two seasons, it is clear that for the next nesting season, patrols need to be carried out every night during the months of December and January, as these are peak times for nesting of marine turtles at CI.

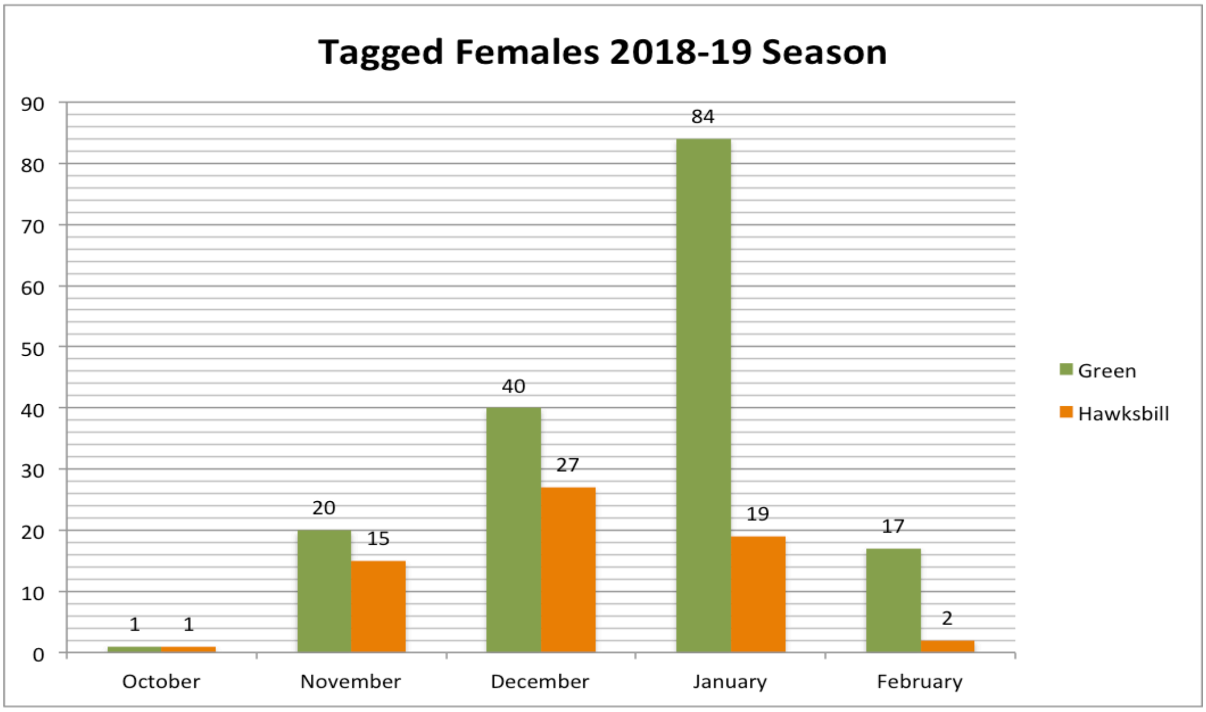

Figure 5. Female Hawksbill and Green turtles tagged over October 2018 – February 2019.

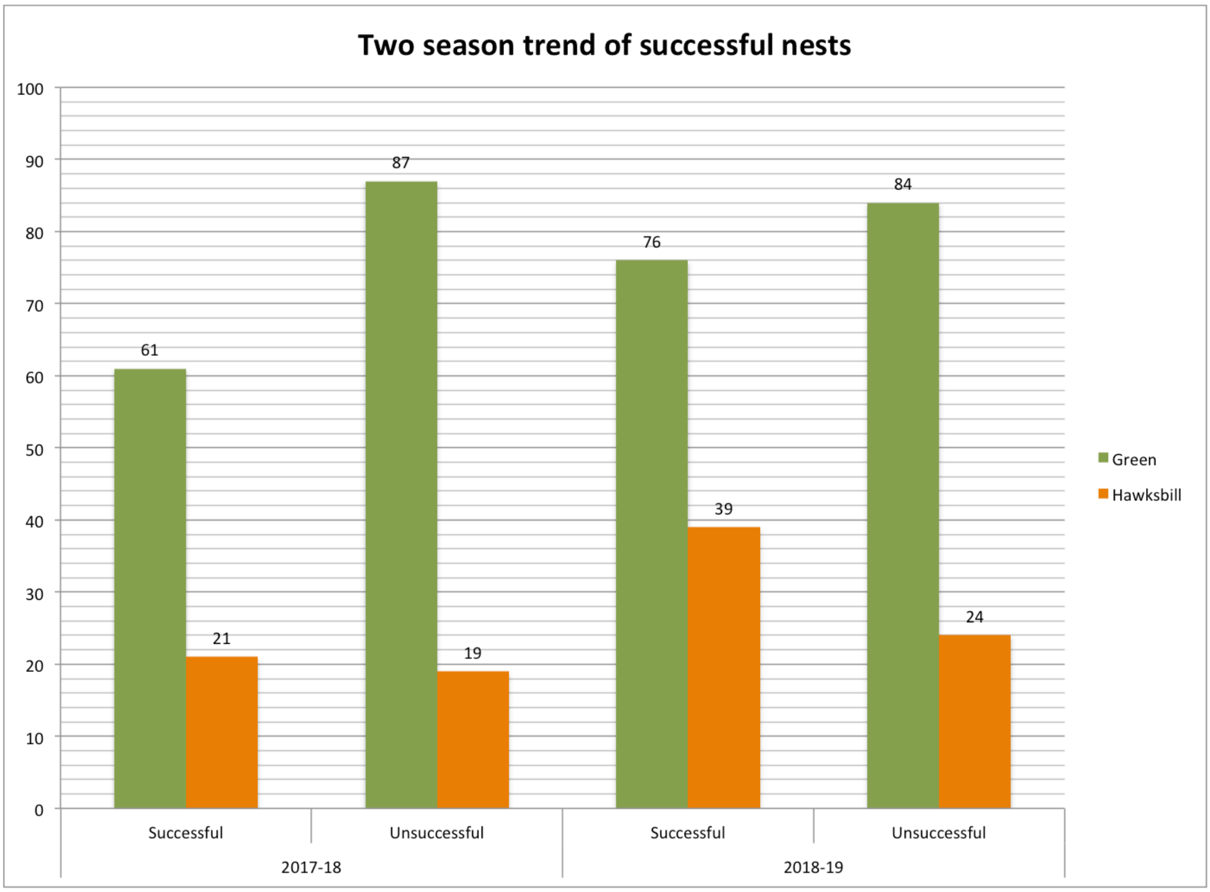

Figure 6. Comparing the number of successful vs. unsuccessful nests in 2017-18 and 2018-19.

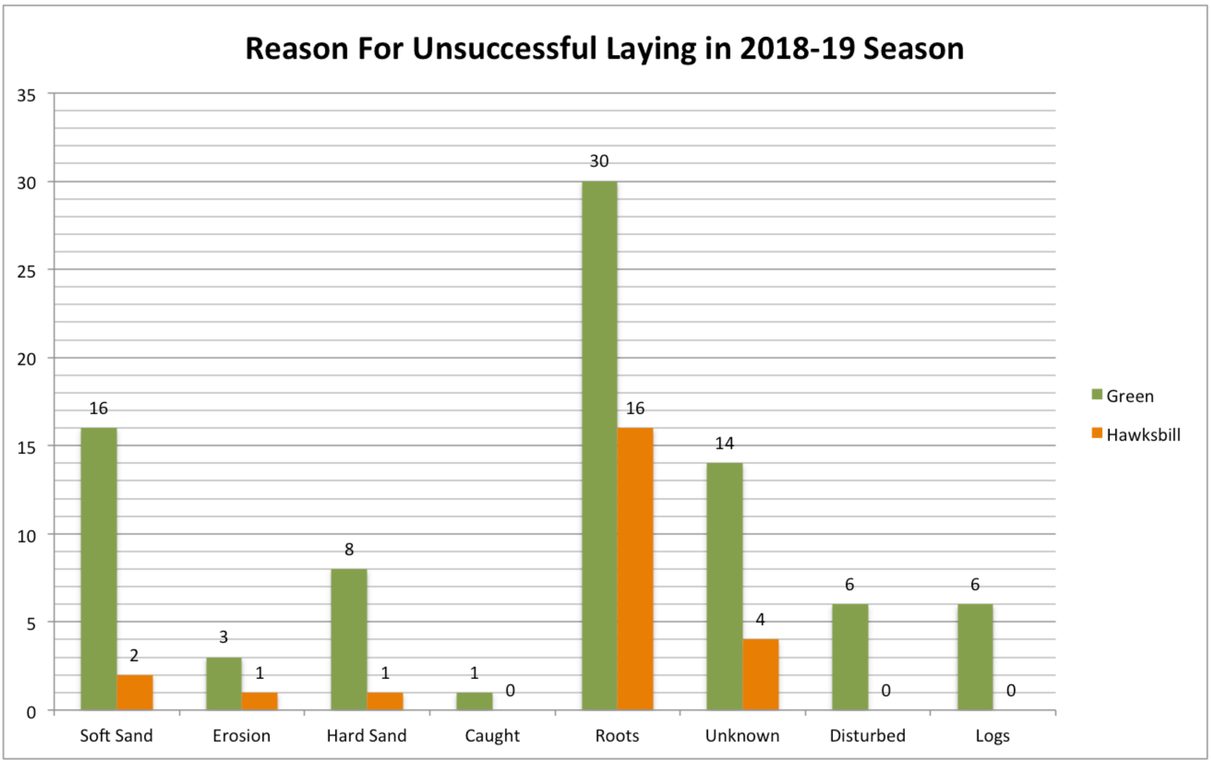

Figure 7. Data on disturbed/unsuccessful nests for Greens and Hawksbills in 2018-19 nesting season.

The nesting female hawksbill turtles had a 60.94% success in laying their eggs on the beaches of CI during 2018-19 season, which was a 7% increase from the previous seasons' successful laying rate (53.85%). Whereas hawksbill unsuccessful nests rate (37.5%) had an 11.22% decrease from the previous season's unsuccessful laying rate (48.72%). The green turtles successful laying rate increased by 29.86% between the two seasons, however their unsuccessful laying rate also increased by 15.21% in the 2018-19 nesting season (Figure 6). This season, hawksbill and green turtles had 23.33% and 7.4% higher rate in laying successfully than unsuccessfully, respectively. Although this is a positive outcome over two seasons, it was mentioned in the last report that discovering the cause of unsuccessful nesting should be implemented in the data collection. From patrollers observing nesting females crawling up the beach and digging their egg chambers, it was noted that 35.71% of green turtles and 66.67% hawksbills did not complete their egg chambers due to tree roots in the sand, which was the most common reason for incomplete/unsuccessful laying (Figure 7). Soft sand played a role in unsuccessful digging for green turtles (19.05%), followed by "unknown" category (16.67%). Hawksbills "unknown" category made up 16.67% of failed nests, followed by soft sand (8.33%).

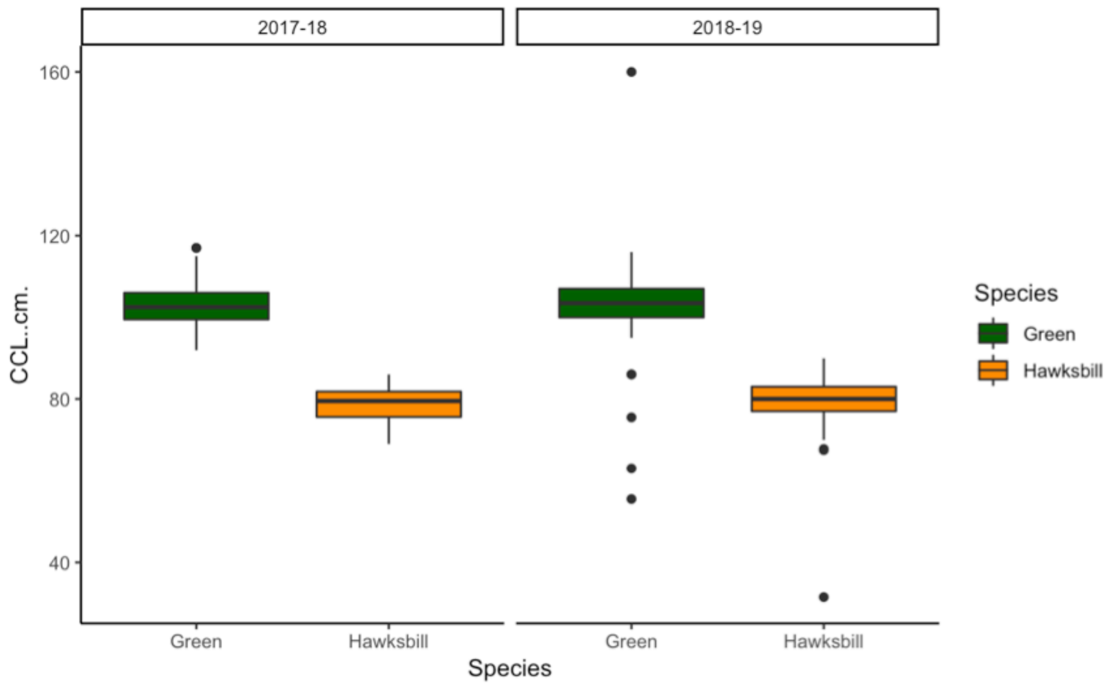

Figure 8. Boxplot of Curved carapace length (CCL) of each species over two nesting seasons.

Over the past two nesting seasons, both the female green and hawksbill CCL (cm) have been very similar in length (Figure 8). In 2018-19 nesting season, outliers in these numbers were found with one female green turtle being a largest recorded on CI, at 160cm CCL and the smallest being 55.5cm CCL. Hawksbill turtles are known to be smaller than green turtles, hence their summary statistics were continually lower, with a maximum 110cm CCL and 31.5cm CCL as the minimum (Table 1). The median and mean for both species were very similar, illustrating a low standard deviation (0.68 and 1 for greens and hawksbills, respectively).

So far, there is no linear correlation between size of CCL (cm) and the number of eggs laid (See figures 9 & 10) with either species, the main clusters for Hawksbill turtles can average a CCL of 70-90 cm having approximately 100-170 eggs per clutch, while greens are clustered around a CCL of 90-115 cm having approximately 70-130 eggs per clutch. Both have large ranges and further data collection and analysis over subsequent nesting seasons will determine if there is a true relationship with these parameters.

Table 1. Summary of Green and Hawksbill CCL (cm) in 2018-19 nesting season.

	Green	**Hawksbill**
Total	158	60
Minimum CCL (cm)	55.5	31.5
1st Quartile CCL (cm)	100	77
Median CCL (cm)	103.5	80
Mean CCL (cm)	103	78.91
3rd Quartile CCL (cm)	107	82.62
Maximum CCL (cm)	160	110

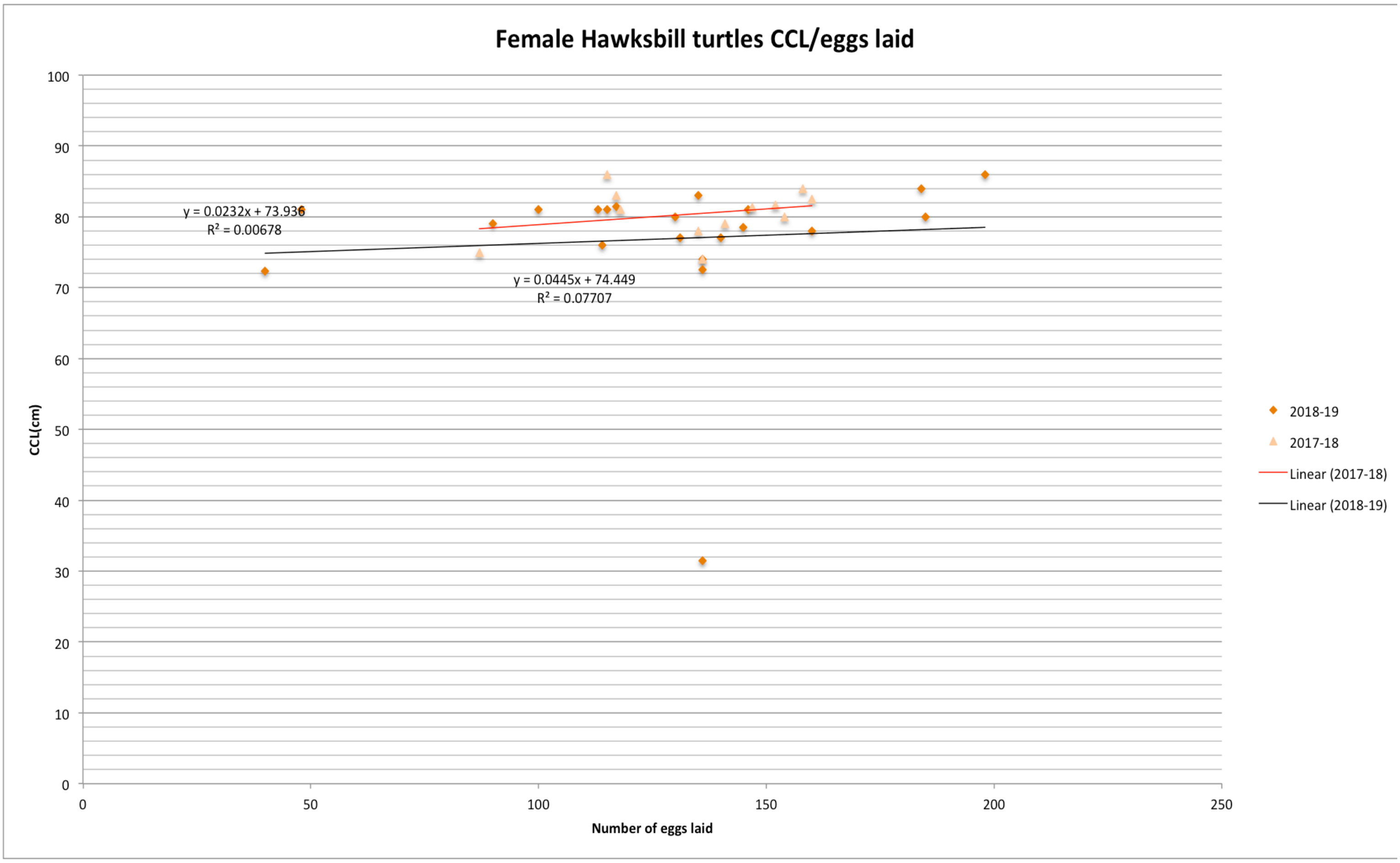

Figure 9. Variation in reproductive output of Hawksbill turtles.

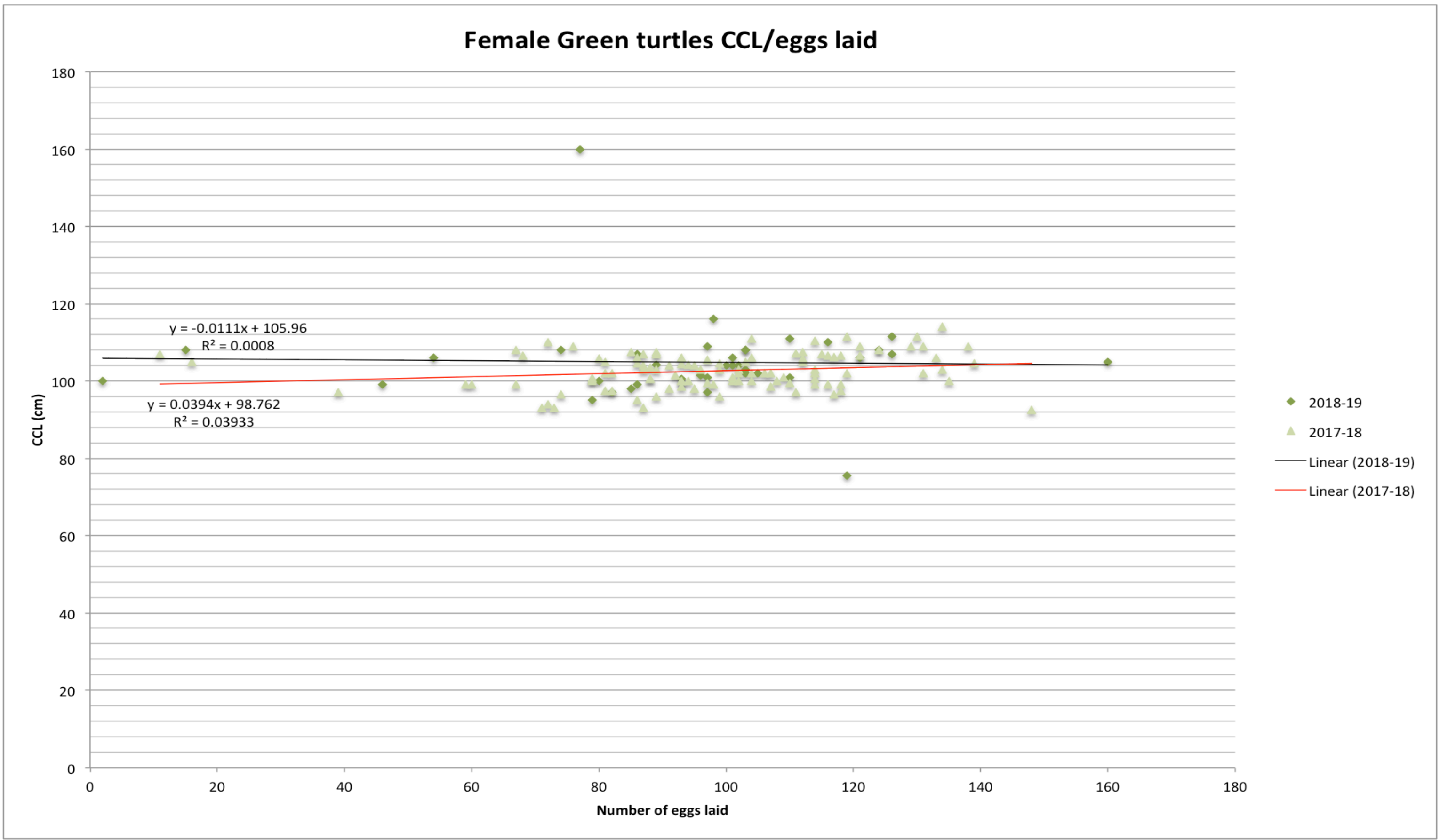

Figure 10. Variation in reproductive output of Green turtles.

Turtle Rodeo

A total of 70 green turtles and 22 hawksbill turtles were caught by rodeo during the months of October 2018 to February 2019. Majority of turtles caught by rodeo have small CCL (cm) and are therefore classified under the age class of juvenile (30 – 60cm CCL) to sub-adult (60-80cm CCL) (Figure 11). Seven sub-adults and one adult turtle were caught during these rodeos, with 74 juveniles in total. Five of the caught turtles had observed existing tags, including the adult turtle (CCL = 101cm). Four of the tags were IGS tags from the previous rodeo season and two were R tags, which is the code for SPREP in Samoa or Alotau, however these tags did not hit in http://www.seaturtle.org/tagfinder so it is unsure of their origin of tagging. The other existing tags were a juvenile green (IGS0280, IGS0279), which had been captured and tagged on the 02/01/18 around Aroroa island, a female nesting on Irai (IGS0609), who laid eggs successfully on the 6/12/18 and another juvenile who was tagged for the first time during a rodeo on the 13/12/18, hence this was the second time caught by rodeo in the season.

For CICI's first season (2017-18), 22 green turtles were successfully tagged via the turtle rodeo method, whereas 64 green turtles were tagged in 2018-19, increasing the tagging efforts via rodeo by 78.05% . Hawksbill tagging via rodeo was not as successful, with only 1 tagged in 2017-18 and 22 tagged in 2018-19, increasing efforts for hawksbill tagging by 95.65%. Of course, with such as slow start, this isn't hard to achieve such a significant jump in tagging efforts via rodeo (Figure 12).

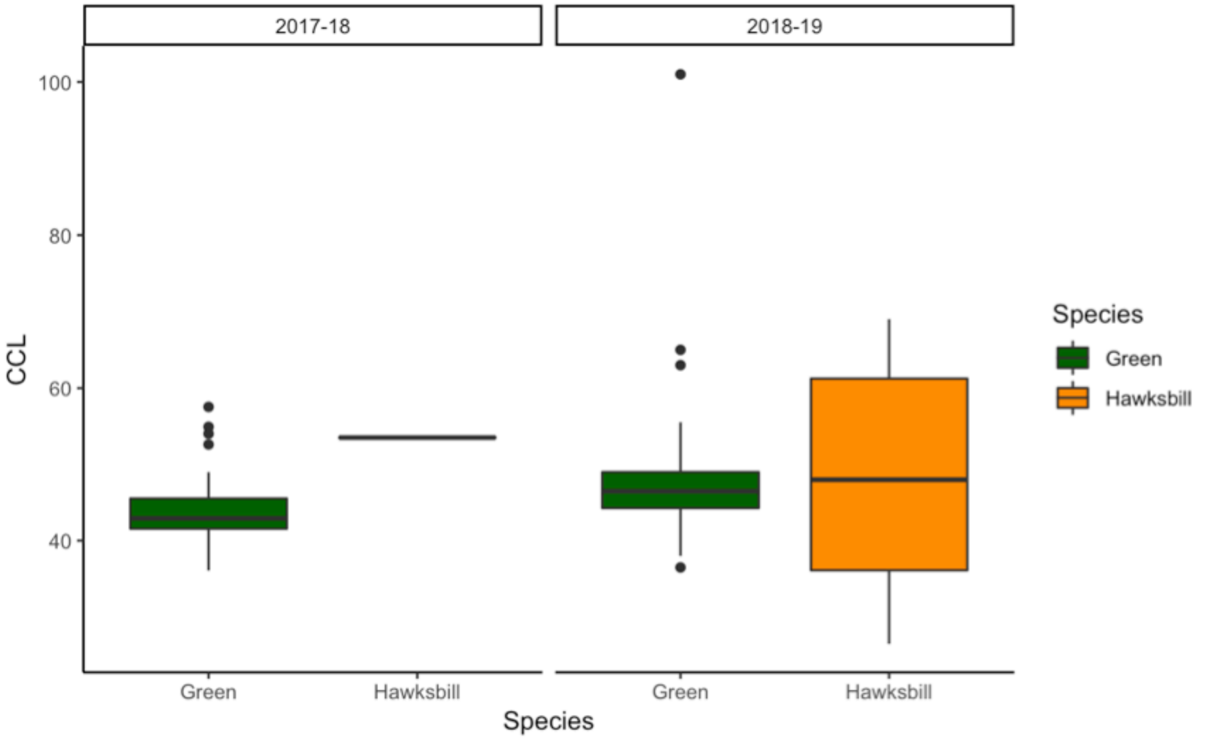

Figure 11. Boxplot of Curved carapace length (CCL) of each caught species over two rodeo seasons.

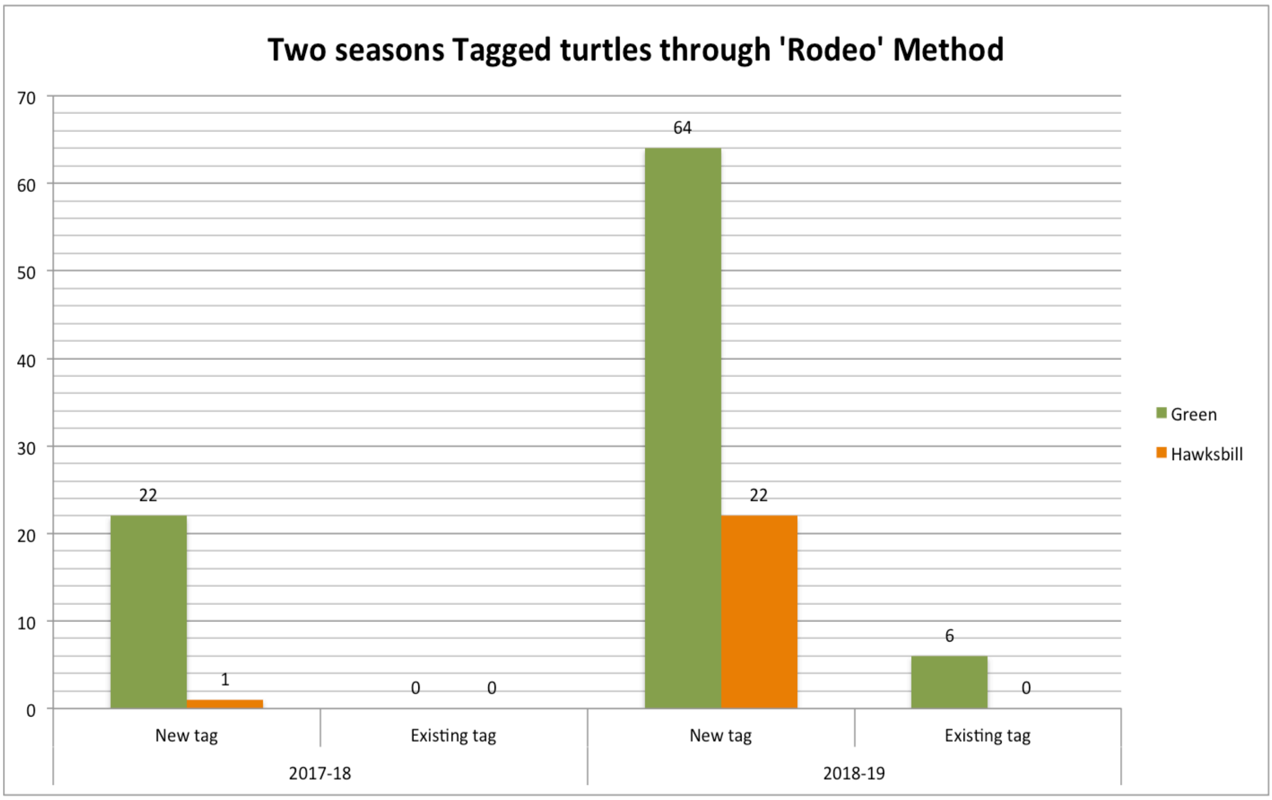

Figure 12. Rodeo of new tags and existing tags within two rodeo seasons.

Hatchlings

The mean weights (g), Body Depth (mm) and CCL (mm) of hawksbill and green hatchlings from each clutch (Tank) are represented below. As expected, it is illustrated that as the weights of the hatchlings increase, so does body depth (BD) and CCL. For hawksbill hatchlings, clutch two and ten had the lowest weight/CCL/BD numbers, whereas clutch 7 had the highest. It is interesting to note that the CCL of the hatchlings were higher than the body depth, meaning that the hatchlings are longer than they are in depth (height) (Figure 13).

For green hatchlings, clutch seven also had the highest weight/CCL/depth, with clutch ten and three being the lowest. Unlike the hawksbills, greens are a factor higher in weight as hatchlings and their BD is greater than their CCL, demonstrating that they are 'thicker' than they are long, which can be a good morphology identifier for comparing hatchling of these species (Figure 14). Unfortunately this was all the data collected for hatchlings on CI besides the hatchling success rate in Melissa Staines research (Stated in *Methods*).

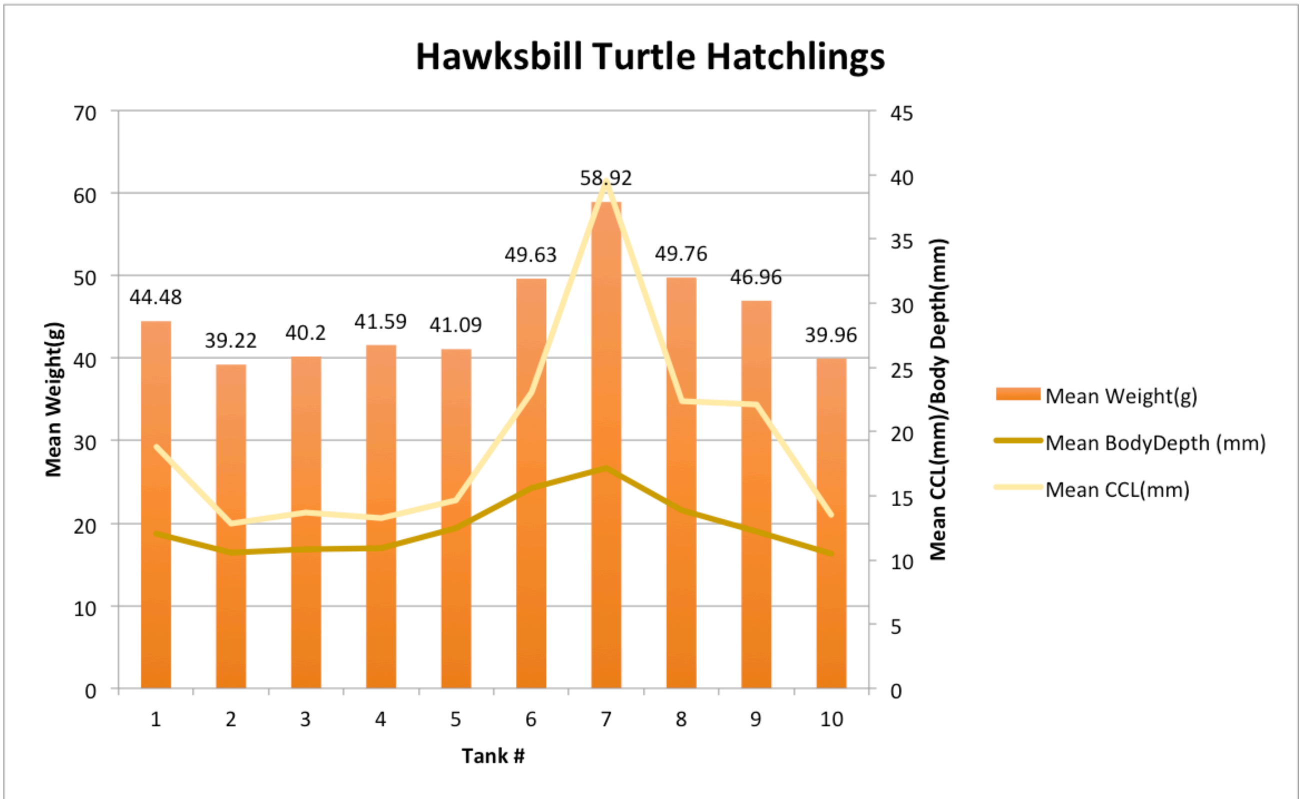

Figure 13. Hawksbill hatchling weight, CCL and Body depth correlation of 10 clutches in 2018-19 season.

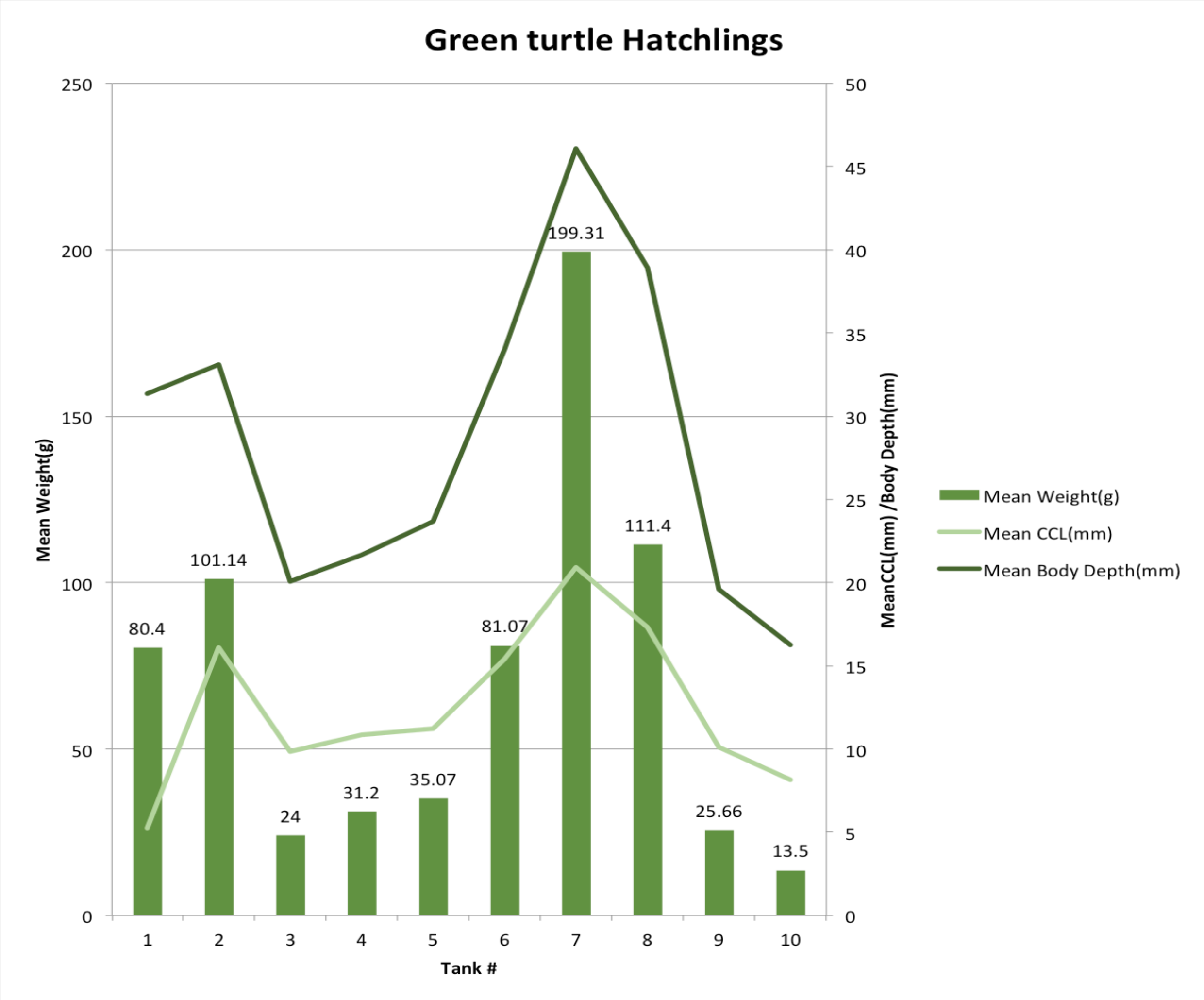

Figure 14. Green hatchling weight, CCL and Body depth correlation of 10 clutches in 2018-19 season.

Discussion

The 2018-19 nesting season for greens and hawksbills on Conflict Islands was a successful year. A total of 226 nesting female turtles, 74 juveniles and seven sub-adults were tagged. Although there are fourteen islands that we surveyed during turtle nesting season (October – February), limitations due to weather, volunteers, accessibility made CICI direct our attentions to 3 main islands; Panasesa, Irai and Tupit. However, the other islands were patrolled when it was safe to do so. In future nesting seasons, CICI will aim to patrol all fourteen islands equally to gain robust data of the turtles nesting on CI. This will undoubtedly give is a clearer picture of approximate numbers of greens and hawksbills using CI as a nesting ground, the reoccurrence rate (through existing tags) and the number of juveniles that remain around CI for foraging during these months. As CICI relies on our intern and volunteer program for patrolling power and financial means in terms of equipment and maintenance, it is imperative that we maintain strong recruitment for this program, and strengthen our affiliations with organisations and industries that give us access to the right audience, including universities, TAFEs, conservation volunteering recruitment agencies, etc.

Tagging success for the 2018-19 nesting season was positive overall, with an increase of new tags on both green and hawksbill turtles from the previous nesting season. There was also an increase in encounters with hawksbills that had existing tags but a decrease of encounters with greens that had existing tags. Due to the tagging program commencing only since October 2017, these results are understandable; in following seasons, encounters with new nesting females without tags would increase as the tagging program commences. Initially, there would be low numbers of returners, especially in consecutive years due to the lifecycle and reproduction rates of these species. However, as the tagging program gains momentum over time, we should see a shift from more newcomers without tags to returners with tags. Hence, as the data shows us, there was a decrease in encounters with greens with existing tags and a spike in numbers of hawksbill encounters (due to their low numbers in the first year of the program). The existing tagged individuals were divided as follows:

Table 2. Existing tags from green (*C. mydas*) and Hawksbill (*E. imbricata*) nesting females in 2018-19 season.

Existing tag origin	*C. mydas*	*E. imbricata*
IGS tags (CI, PNG)	44	10
R tags (SPREP, Samoa)	26	8
QA tags (QLD, Australia)	0	2

44 greens and 10 hawksbills had been previously nested on CI in 2017-18. They did not have an interval of several years between breeding seasons, which is defined in the literature of marine turtle's life cycles (*see* Pearse et al 2001, Limpus et al 1994, Kuchling 2012). The connectivity between turtles in Queensland, PNG and Samoa further highlights the need to protect foraging and nesting habitats in all three countries for the conservation and persistence of these two species of marine turtles in the Pacific region. WWF SATELLITE TRACKING DATA FROM CHRISTINE HOF HERE.

Curved-carapace length (CCL) did not show any significant correlations with the number of eggs laid by each species (Figures 9 & 10). However, over time and as more data is collected (n increases), a linear pattern may emerge as seen throughout the literature (*see* Bjorndal 1995, Lutz et al 2002, Broderick et al 2003, Spotila 2004). The outlier in the Hawksbill graph (of the 2018-19 season) is most likely human error as the CCL measured is in the juvenile age-class range of this species, so it would not have reached sexual maturity, hence this is plateauing the positive linear correlation.

Nesting success rates were mixed between species; of the 162 green turtles, 76 were recorded as being successful in laying eggs and for the 64 hawksbills, 39 laid eggs successfully. Both were increases in laying success rates from the previous season, however, unsuccessful nests were also high for both species. Although nesting green turtles were encountered more often than hawksbills, the hawksbills had a higher success rate (60.94%) than greens (46.9%). This difference could be due to the sample sizes (n) of each species, rather than hawksbills being better at determining adequate nesting habitats. Although past research has looked into the nesting preferences of hawksbill turtles in terms of beach accesses with respect to distance from the tree line and water line (See Kamel et al 2005), this was directed at hatchling success and should be studied along with other morphological traits such as egg size, egg number and the trade off between the two. Nest site preference often determines fitness levels of the female, mainly through her offspring survival. Another study observed repeatability in microhabitat choice; that hawksbill females did just return to the same location along a shoreline, that they chose the same microhabitat each season they came up to lay (Kamel et al 2006).

Last year it was noted that CICI should identify reasons why nests were unsuccessful on the beaches. This was implemented in the 2018-19 turtle program and patrollers were given options of habitat type and/or disturbance categories as to why turtles abandoned their efforts. The most prominent recording as to why turtles did not lay eggs was due to tree roots in the sand. Around 1/3 of green turtles and 2/3 hawksbills did not lay successfully due to tree roots disturbing them while digging their egg chambers. Soft sand was also an issue, with turtles abandoning their efforts and returning to the ocean. If these females have microhabitat nesting site preference as aforementioned, the obstructing roots within these microhabitats of choice will present a future problem for nesting success in the Conflict Islands.

Erosion is the main affect behind tree root exposure on nesting beaches. The Conflict islands atoll is visibly affected by the movement of sand from tidal surges during the cyclonic months of the season and also the issue of rising sea levels from anthropogenic climate change. Studies that modelled the grave affects of sea-level rise (SLR) on turtle rookeries where nesting beaches were inundated with salt water and egg mortality increased significantly (Fish et al 2004, Fuentes et al 2010). It was found in El Salvador and Nicaragua that most hawksbills preferred nesting sites with abundant vegetation and mangrove estuaries, while in the Indo-Pacific and Caribbean, they prefer open-coast beaches near coral reefs, indicating that different rookeries around the world prefer different habitats and can exhibit local adaptations to differences in nesting habitats (Liles et al 2015). The most vulnerable places that will be highly affected by SLR are smaller, low-lying islands. Hence, the Conflict Group and its turtle rookeries will be continuously affected by climate change in the form of SLR. Manipulating the habitat around the beaches of CI is one short-term resolution CICI can accomplish. For example, shifting more sand and creating more sandy areas close to the foliage and removing obstructing tree roots in known nesting sites will mitigate problems for some of the females during nesting. Another option would be to create more hatcheries for "high-risk" nests, however this is once again only a short-term solution to a long-term, global problem.

Turtle "Rodeos" are also necessary for collecting data in the area selected for conservation. Looking further than active rookeries, rodeos give information about the marine habitat utilised by adult females, juveniles and adult males. Assessing whether the reef and lagoons around CI are preferred foraging grounds for annually will strengthen grounds for protection under a Local Marine Protected Area (LMPA). Juvenile green and hawksbill turtles are often observed outside of nesting season (*pers. obs.*), alluding to healthy foraging habitats around the CI that should be protected for these endangered species. Tagging juveniles now will also give future CICI data collectors the opportunity to observe whether these individuals have hatched on CI and consequently return to nest, or if they are from other Pacific rookeries and move off to other nesting grounds when they reach sexual maturity. Therefore, sharing tagging information with other marine turtle conservation organisations and institutions is paramount to the successful understanding of marine turtle movement and habitat preference around the Pacific.

It is clear that the 2018-19 data collection was missed due to a number of issues in the hatcheries and nursery over the season. However, CICI aims to carry out more data collection in the following 2019-20 turtle season. MELISSA STAINES PROJECT RESULTS HERE

Looking towards the upcoming season, CICI will collect more data on the hatcheries in terms of sand temperatures and mortality rates with the emerging hatchlings. Sand temperatures are increasing due to global anthropogenic climate change. As ectotherms, marine turtles and other reptiles rely on the ambient environment for their life-history traits, behaviour and physiology (Spotila & Standor, 1985, Fuentes et al 2011). Hence, changes to their environment through their vulnerable embryonic developmental stage could mean higher mortality rates of hatchlings, sex-ratio alterations (Morreale et al 1982, Booth & Freeman 2006, Rafferty & Reina 2014, Jensen et al 2018, Patricio et al 2019) and swimming performance alterations by increased sand temperatures (Burgess et al 2006). Feminisation of marine turtles due to increasing temperatures is a very large concern for the persistence of these species in the future. The placement of eggs in the egg chamber has been a well-studied indication of sex ratios, where the cooler temperatures (bottom of the clutch), produce males and the warmer temperatures (top of the clutch), produce females

(Figure 15) (Broderick et al 2000, Booth & Freeman 2006, Godfrey & Mrosovsky 2006, Miller & Limpus 1981, Glen & Mrosovsky 2004, Kamel & Mrosovsky 2006). Hence, if the temperature of the sand continues to increase at unprecedented rates due to anthropogenic climate change, the rate and resilience of marine turtles coping with this change is unknown (Hawkes et al 2009). Therefore, CICI will carry out the following two projects in the 2019-20 season:

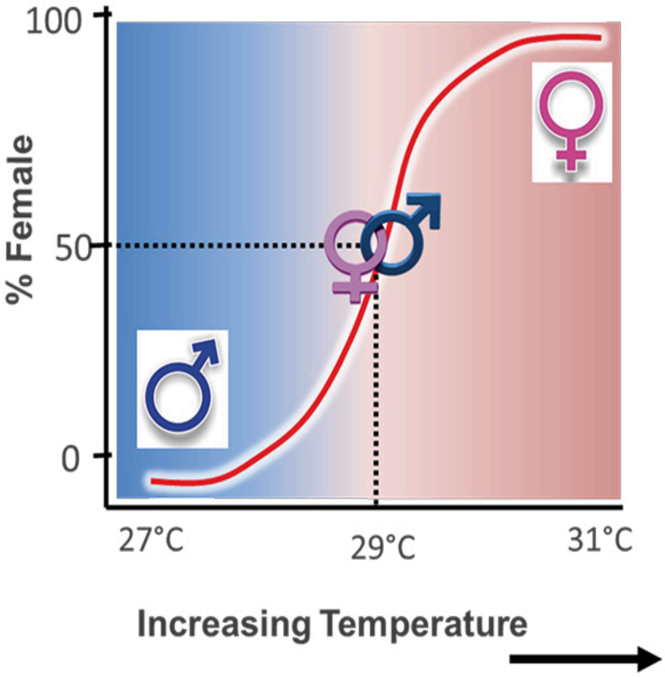

Figure 15. Marine turtle sex-ratio temperature dependence chart (*adapted from* Morreale et al 1982)

PROJECT 1: CICI will also look at the embryonic development (using Miller et al 2017) of the deceased embryos to establish when the hatchlings are at their most vulnerable developing within the egg. The hatcheries located on CICI are all either under a built roof or shaded by surrounding trees. From the results of Melissa Staines (UQ) project, CICI will follow the successful methodology to allow for maximum successful emergence. CICI will continue to collate this data for future assessment and long-term conservation management. Within the nursery, hatchlings will be weighed measured and their tank temperature, pH and salinity recorded as usual.

PROJECT 2 (Steven's project): To detect whether the nursery is working at maximum efficiency with hatchlings growing at a healthy rate, recoding the morphological measurements of specific nests (n=12) for 3 months prior to their release. This will give CICI a better understanding of the growth rates of both species and if there are any quantitative measures (e.g. optimum temperature, pH and salinity, water flow, etc.) that should be provided or avoided. CICI aims to partner with turtle health expert, Dr Ellen Ariel and Karina Jones of James Cook University for these projects, including collecting the data through our turtle internship program.

Overall, CICI's turtle tagging and monitoring program continues to provide interesting information in this highly diverse area of Milne Bay, PNG. Although there weren't as many endangered green turtles encountered and tagged compared to the previous season, critically-endangered hawksbill encounters and tagging have increased by 18.49%, allowing access to information on their nesting habits and behaviour in the future. The ability to collect data during patrolling and protecting turtles throughout nesting seasons gives CICI more power in it's promise to create a LMPA around Conflict Islands. Government support, CICI staff and internships from national and international industries are crucial for this collaborative effort, and the more CICI and partners can prove how active and significant the reefs and beaches (islands) are at CI, the better chance of implementing sustainable management strategies that will directly and indirectly affect surrounding island communities.

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