CEA/OPERATION WALLACEA IMMATURE GREEN SEA TURTLE

MONITORING REPORT 2014

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Abstract

Sea turtles are increasingly popular as a form of wildlife tourism, but little is known about the effect of tourism on turtle behaviour. Data from other wild species suggests that if tourism is not correctly managed, interactions with tourists can lead to behavioural changes and increased anxiety in the target animals. Immature turtles are known to aggregate around areas of sea grasses in relatively shallow water, making them accessible to swim and snorkel based tourism. However, these turtles can also migrate from these feeding zones once their preferred food sources have become depleted. Successful management of tourism involving immature turtles therefore requires careful management of both tourists and sea grasses. This current study aimed to investigate the effect of tourism on activity budgets of immature green turtles (*Chelonia mydas*) in Akumal Bay, Mexico and to investigate turtle feeding preferences and possible overgrazing of specific sea grass species. Behavioural data were collected on 30 immature green turtles that were all individually identified using focal animal sampling with instantaneous recording at 1-minute intervals. In addition, 52 quadrat surveys of sea grass coverage and biomass were conducted at randomly selected sites within the bay. Results indicated that there was a significant reduction in feeding behaviour when tourists were present, but this effect did not increase exponentially as tourist numbers increased. Anecdotal reports of tourist attempting to interact with turtles, produced notable evasive responses. Turtles showed a clear preference for feeding on *Thallassia testudinum* despite the fact that this was not the most abundant species of sea grass. All patches of *Thallassia testudinum* were heavily grazed suggesting that the number of turtles feeding on this species may soon exceed the carrying capacity. Future studies will aim to investigate both the behaviour of tourists and turtles in an attempt to quantify the frequency of attempted or successful interactions with the turtles and the behaviour responses they elicit. Future management of the sea grasses could include trimming of other sea grass species to encourage new growth as this may attract the turtles and reduce the grazing pressure on *Thallassia testudinum*.

Introduction and Project Rationale

Turtles and ecotourism

Many captive animals have been reported to show signs of stress when human observers crowd their environment (Carder & Semple, 2008; Davis et al., 2005; Fernandez, et al., 2009). Animal stress levels appear to be most affected by sudden changes to their environment such as peaks in tourism during otherwise quiet periods (Davis et al., 2005) or when the behaviour of human observers is perceived as threatening by the animals such as attempting physical contact with the animal or blocking the animal from an escape route (Fernandez et al., 2009). Increased anxiety associated with tourism can be reduced in zoo settings by correct management of tourism numbers (Hosey et al., 2013) and the introduction of environmental enrichment to enclosures to distract the animals from zoo visitors (Carlstead & Shepherdson, 2000; Carder & Semple, 2008; Hosey et al., 2013). The effect of tourism on wild animals on the other hand, is more difficult to control.

Primates are a popular choice for wildlife based tourism, but recent studies have indicated that attempts to interact with wild primates can cause an increase in both behavioural (self-scratching) and hormonal (cortisol) indicators of elevated stress levels (Marechal et al., 2011) and in some cases, just proximity to human settlements can cause increased levels of stress hormones (Rangel-Negrin et al., 2009). Sea life, in particular dolphins are also ever increasingly popular ecotourism attractions and studies of dolphin behavioural responses to tourism have indicated that tourism management is vital if the ecotourism is to be sustainable in the long-term. A study of behavioural responses of female dolphins to tourism found no changes to dolphin behaviour when 1-2 tourist boats were present, but erratic and evasive movement patterns were observed when the number of tourist boats increased or when attempts were made to swim with the dolphins (Stensland & Bergren, 2007). Similarly, a long-term study of wild dolphin responses to swim attempts from commercial “swim with dolphins” based tourism indicated that dolphin avoidance behaviour increased over time as the level of tourism increased (Constantine, 2001). As these animals are not in a captive setting and have control over their ranging patterns, long-term exposure to increased anxiety associated with tourism could cause the animals to abandon their home range in favour of an area with less disturbance. Evidence to support this claim has been provided by long-term dolphin population monitoring in Shark Bay in Australia, where a decline in dolphin abundance was reported in areas where boat based tourism had increased (Bedjer et al., 2006).

Like dolphins, sea turtles have become increasingly popular as targets of tourism (Wilson & Tisdell, 2001). All sea turtles are classed as endangered or critically endangered (IUCN, 2012) and are threatened by habitat loss, human consumption and other human activities such as fishing. Sea turtle orientated ecotourism has proved extremely beneficial to sea turtle conservation as it has enabled local communities to benefit from sea turtle populations in a non-consumptive way (Wilson & Tisdell, 2001). However, in most cases, turtle based tourism is focused on nesting females who are only subject to human observers for a short period of time, and very little is known about the impact of constant or long-term exposure to tourism on sea turtle welfare (Tisdell & Wilson, 2002). Immature turtles aggregate around sea grass feeding grounds (Arthur et al., 2008) creating a year-round presence in these area. If these feeding zones are in touristic areas then there is huge potential for dive and snorkel based tourism to swim with these turtles. However, if such tourism is not properly managed, then turtle welfare could be negatively affected or it is possible that the turtles will simply abandon the area.

Foraging behaviour of immature green turtles

Sea turtles spend over 90% of their time far out to sea where they are largely inaccessible. Consequently, little is known about their behaviour, diet and habitat preferences. Green turtles (*Chelonia mydas*) are generally herbivorous with sea grass and algae as the main components of their diet (Lopez-Mendilaharsu et al., 2005) although data from animal-borne video cameras suggests that ctenophores and jellyfish are also important components of their diet (Heithaus et al., 2002). The diet and behaviour of green turtles are reported to change from the juvenile to adult life stages, with a more varied diet in adult turtles, whereas juveniles and sub-adults feed exclusively on sea grasses (Thomas et al., 2001; Arthur et al., 2008).

A study of immature green turtle stomach contents indicated that over 80% of the diet consisted of sea-grasses with the majority being from the *Thalassia* genus (Mortimer, 1981). As with all grazing animals, turtles show a strong preferences for younger parts of the plants that have a higher nutritional content and are more easily digested (Bjorndal, 1980). Continuous grazing of turtles on the same sea grass patches maximises the nitrogen and protein content in the grass and decreases the lignin content by around 50% (Dawes, 1979; Bjorndal, 1980). The low lignin content is key because lignin is responsible for decreasing digestibility (Zieman et al, 1984). This mutualistic relationship between plant and grazer has been reported in a wide range of terrestrial herbivores (c.f. Detling, 1998), but the relationship starts to break down if he density of grazers exceeds the carrying capacity of the vegetation (c.f. Fritz & Duncan, 1994).

Aims and objectives of immature green turtle behavioural study in Akumal Bay

There are no known studies that focus on the impact of dive and snorkel based tourism on the behaviour of sea turtles. This current study aims to investigate the impact of tourism on the activity budgets and feeding behaviour of immature green turtles (*Chelonia mydas*) aggregating around a sea grass feeding zone in Akumal Bay in the Yucatan Pensinsula of Mexico. Akumal Bay is a popular location for tourists and as the area of sea grass is just a few metres from the shoreline, snorkel based tourism to observe the immature green turtles has increased exponentially in the last few years. However, it is unclear if the presence of tourist has a significant effect of turtle behaviour or if tourism has an influence on the preferred feeding zones of the turtles. In order to ensure the continued protection of these turtles, it is also necessary to monitor their grazing of the sea grasses in relation to the relative abundance of each species; *Thallassia testudinum, Siryngodium filiforme* and *Halodule wrightii*, to determine if current grazing rates are sustainable in the long-term. It is predicted that there will be a significant change to turtle activity budget, specifically the percentage of time spent swimming and feeding will be affected by the presence of tourists. As with other grazing animals, when turtles feed their head is down and they are unable to scan their surroundings. If turtles feel vulnerable when tourist are present then they are unlikely to want to engage in this behaviour. Similarly, if turtles are uncomfortable about the presence of tourists then they are likely to spend more time swimming in an attempt to move away from their human observers. Both feeding and swimming behaviour are expected to correlate with the number of tourists present. It is also predicted that the turtles will show a clear feeding preference for a particular type of sea grass and therefore show preference for one of the two feeding zones. If turtles are overgrazing one particular type of sea grass then their feeding preference will be irrespective of the abundance of their preferred sea grass and the biomass of sea grass will be different from the percentage coverage (because the biomass will reflect the height of the sea grasses and therefore reflect the level of grazing).

Methods

Subjects and study site

Akumal (meaning "home of the turtles") is a small coastal town located approximately a 1.5 hour drive south from the major tourist destination of Cancun. There are 4 bays in Akumal (aventuras bay, akumal bay, jade bay and half moon bay) and a beautiful lagoon called Yal Ku to the north of half moon bay (Figure 1). Centro Ecologico Akumal (CEA) is a Mexican NGO that is responsible for managing 50km of coastline that covers some of the most important turtle nesting sites in the Caribbean. CEA is located within a 4 hectare compound in the northern part of Akumal bay. In 1993, Centro Ecológico Akumal (CEA) began its conservation activities and operates its Sea Turtle Protection program through permission from the Wildlife Agency. Three species can regularly be found around Akumal. Local beaches are nesting ground for two of these species: the Loggerhead Turtle (*Caretta caretta*) and the Green Turtle (*Chelonia mydas*). The Hawksbill Turtle (*Eretmochelys imbricate*) can be found feeding around the reef and year-round you can find juvenile green turtles feeding on sea grasses in the bays.

At the end of 2006, CEA began monitoring juvenile green turtles in Akumal Bay. This is a key foraging area due to the abundant sea grasses. The local population in the bay fluctuates, with as many as 43 individual turtles present at a time. The increase in numbers of juvenile Green turtles in Akumal has resulted in an increase in tourists coming to see them causing concern for the welfare of the turtles. In addition, there is concern that the turtles are overgrazing the sea grasses in Akumal Bay.

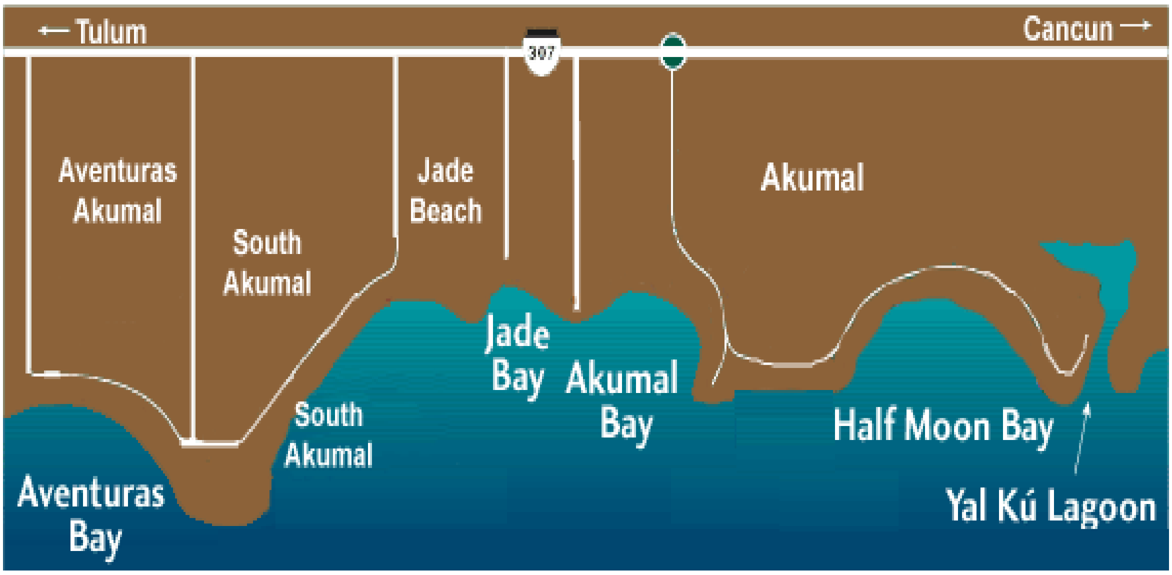


Figure 1: Map of Akumal showing location of the bays and Yal Ku lagoon. Centro Ecologico Akumal is located in Akumal bay.

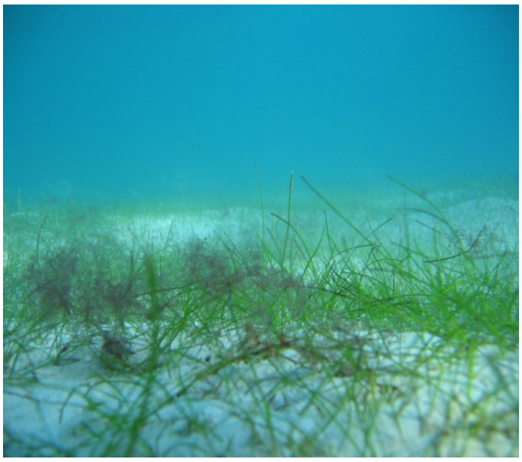
Data Collection

Data were collected on the resident immature green turtle (*Chelonia mydas*) population in Akumal Bay. Akumal Bay can be divided into two distinct feeding zones based on geographical location and the predominant species of sea grasses (Figures 1a and 1b). Zone T is closer to the coast, does not exceed 2 meters in depth, and is strongly affected by waves that stir up sediment and impair visibility. However, these waves are rarely large waves because the bay is protected by the coral reef. The sea grasses in Zone T are predominantly fanerógama (*Thalassia testudinum:* Figures 2a and 2b). Zone S is situation much closer to the reef and thus the waves are almost undetectable, which keeps the visibility stable. Depths in Zone S are generally between 2-3 meters. The sea grasses in Zone S are predominantly fanerógama filiformes (*Siryngodium filiforme* and *Hadolule wrigthii* Figure 3a and 3b).

Behavioural observations of turtles were broken down into a series of 2-hour periods between 7am and 7pm resulting in 6 different time slots in total. Three time slots were used each day and rotated to ensure that equal quantities of data are collected for each time of day (e.g. day 1: 7am-9am, 11am-1pm, 3pm-5pm then day 2: 9am-11am, 1pm-3pm, 5pm-7pm). When a turtle was located photographs of the head and back of the turtle and a zoomed photograph of the numbered tag on the turtle will be recorded for use in the existing turtle ID database.

Figures 1a and 1b: Feeding zones in Akumal Bay

Figures 2a and 2b: *Thalassia testudinum* in Akumal Bay

Figures 3a and 3b: *Halodule wrightii* in Akumal Bay

Behavioural data were collected while snorkelling in the bay using focal animal sampling with instantaneous recording (Altmann, 1974), whereby each student followed a different individual turtle for a 20 minute period and recorded its behaviour at 1-minute intervals based on pre-defined behavioural categories (Table 1). The aim was to complete two 20 minute focal samples per hour with the remaining time spent locating and identifying each turtle. When the turtle was feeding, the type of sea grass was recorded (*Thallassia testudinum* or *Siryngodium filiforme/Halodule wrightii*). Weather characteristics (sunny, cloudy, rainy, etc.), feeding zone (T or S), approximate depth of the turtle, and visibility in the area (normal, bad or good) were recorded for each 1-minute interval. The number of tourists within a 5 meter radius of the turtle was recorded for each 1-minute interval. If the turtle moved out of view for up to 3 minutes then their behaviour was recorded as "out of view" and the data collection resumed as soon as the turtle was visible again. If the turtle remained out of view for longer than 3 minutes then the sample was abandoned. Focal samples less that 5 minutes in duration were discarded, but anything longer than 5 minutes were kept and the exact duration of the sample recorded.

Table 1: Ethogram of turtle behaviour

Behaviour	Description
Feed	Turtle masticates food while food is in its mouth or is foraging on prey items
Swim	Turtle moves through the water in restively horizontal position
Rest	Turtle is stationary and is not engaged in any other behaviour
Social	All forms of social interaction with one or more individuals
Surface	Turtle swims in a roughly vertical position towards the water surface to breathe
Dive	Turtle swims quickly in a roughly vertical downward position

In order to assess turtle feeding preferences and potential overgrazing of sea grasses, it was first necessary to determine the relative abundance of each food type (*Thallassia testudinum,* and *Siryngodium* *filiforme/Halodule wrightii*) in each feeding zone. As it was not possible to differentiate between the two types of fanerógama filiformes, and thus *Siryngodium filiforme* and *Halodule wrightii* were treated as the same food type. Fifteen quadrats, each 1m^2, with 20cm sub-division (i.e. 25 small squares inside the quadrat) were randomly placed in each of the two feeding zones (30 quadrats in total). In each quadrat, the number of small squares that were covered by each type of sea grass or bare sand were recorded. In addition, a graduated touch pole was used to assess the height of the sea grass in each small square.

Data Analyses

As each turtle could be individually identified, data were collected at the individual level and then summarized across individuals to create mean values for statistical comparison. A total of 46 turtles could be reliable identified from photographs and tag numbers (see Appendix A), but only thirty turtles had a sufficient number of observations (> 1 hour) to be included in the analyses. The mean (± SEM) percentage of scans spent in each activity (diving, feeding, resting, social, surfacing, and swimming) were presented graphically. To test the prediction that feeding and swimming behaviour would be affected by tourist presence, data for each turtle were divided into two groups: no tourists and tourists present. The mean percentage of scans spent feeding with and without tourists was compared using a paired t-test on arcsine transformed data. The same method was used to compare swimming with and without tourists. To test the prediction that the percentage of time spent swimming and feeding would correlate with the number of tourists present, data for each turtle were grouped according to the number of tourists present (0-10) and the total number of behavioural scan recorded for each turtle for each number of tourist present was calculated. From this, the percentage of scans spent feeding for each number of tourist present could be calculated. As there were only a small number of cases were more than 10 tourists were within 5m of the turtle, these data were not included in the analyses. The percentage of scans spent feeding in relation to the number of tourists present was compared using Pearson's correlation coefficient on arcsine transformed data. The same procedure was repeated for swimming.

In order to investigate turtle feeding preferences, the activity budgets of each turtle were then divided according to the feeding zone (Zone S or Zone T) in which the turtle was located and mean (± SEM) activity budgets for the two different feeding zones were presented graphically. The percentage of time spent feeding in each feeding zone was compared using a paired-test on arcsine transformed data. The percentage of scans spent feeding on each sea grass type (*Thallassia testudinum,* and *Siryngodium filiforme/Halodule wrightii*) in each of the feeding zones were compare using General Linear Model on arcsine transformed data with feeding zone as the independent measure and the percentage of scans spent feeding on each sea grass type as the repeated measure. From the sea grass quadrat data, the mean (±SEM) percentage coverage and mean biomass of each sea grass type (*Thallassia testudinum,* and *Siryngodium filiforme/Halodule wrightii*)) were calculated for each feeding zone and presented graphically. Differences in mean percentage coverage of each type of sea grass in each feeding zone were compared using General Linear Model on arcsine transformed data with feeding zone as the independent measure and percentage coverage of sea grass type as the repeated measure. This method was repeated for mean biomass of each type of sea grass. To investigate whether turtle feeding preferences were related to the availability of each sea grass type, the mean percentage coverage of each sea grass type was used as the expected percentage of scans that each turtle should spend feeding on it. For example, if the mean percentage coverage of *Thallassia testudinum* grass was 50% then we would expect each turtle to spend approximately 50% of their time feeding on *Thallassia testudinum* grass. A binomial test was used to determine whether the turtles spent more time than expected feeding on their preferred type of sea grass based on its availability.

Results

Turtle activity budgets and tourist presence

The immature green turtles in Akumal Bay spent the majority of their time feeding, accounting for nearly 70% of their daily activity budget (Figure 4). As predicted, the percentage of scans spent feeding was significantly affected by the presence of tourists ($t_{(1, 29)} = 2.796$, $p = 0.009$: Figure 5), but the presence of tourists had no significant effect on the percentage of scans spent swimming ($t_{(1, 29)} = 1.182$, $p = 0.247$). Contrary to prediction, the percentage of scans spent feeding and swimming did not correlate with the number of tourists present (feeding: $r = 0.179$, $N = 11$, $p = 0.600$, Figure 6; swimming: $r = 0.043$, $N = 11$, $p = 0.900$, Figure 7).

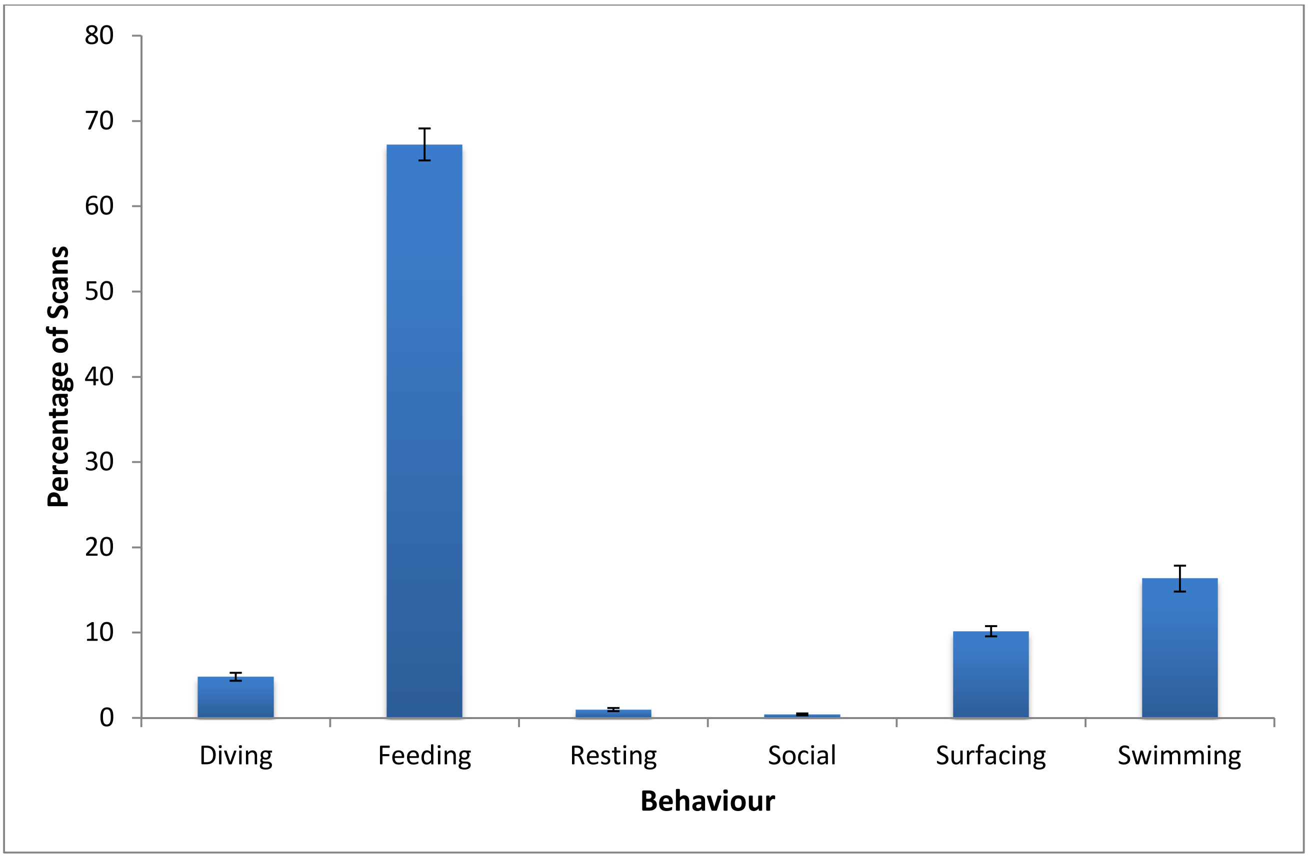


Figure 4: Mean (±SEM) activity budgets for immature green turtles in Akumal Bay

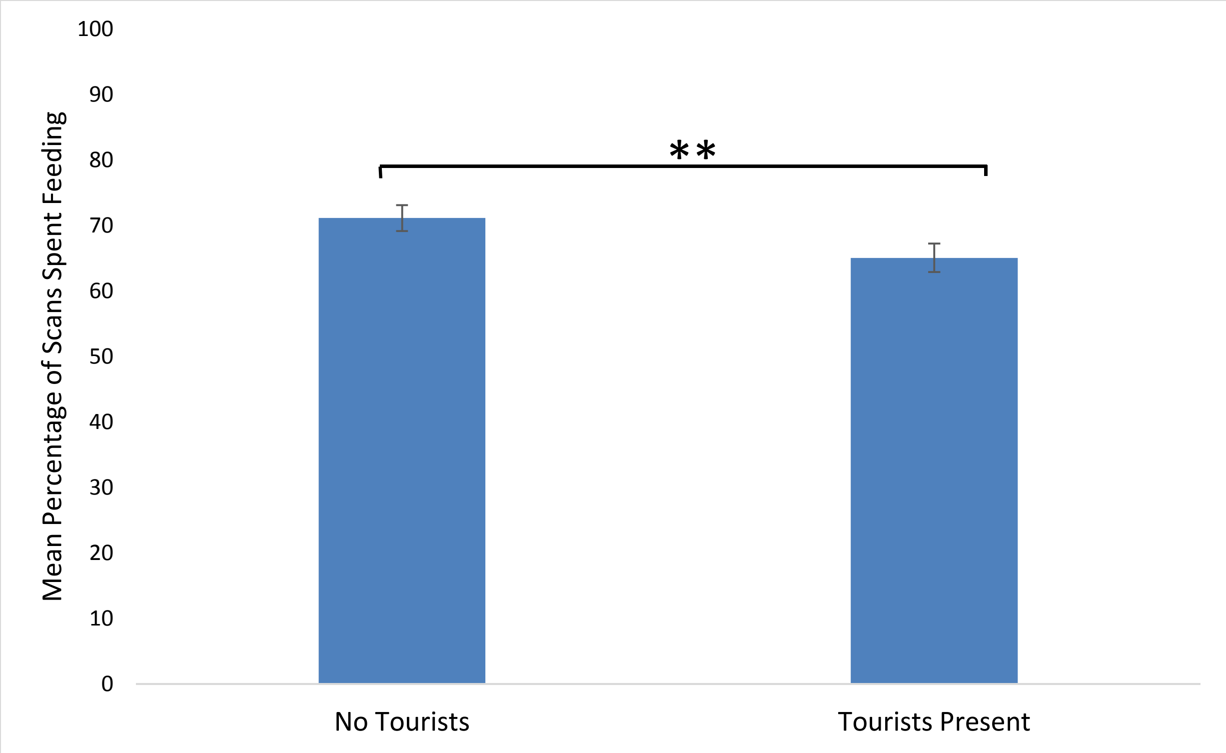


Figure 5: Mean (±SEM) percentage of scans spent feeding with tourist were and were not present. Tourist presence was defined as being within 5m of the turtle. ** indicates significance <0.01.

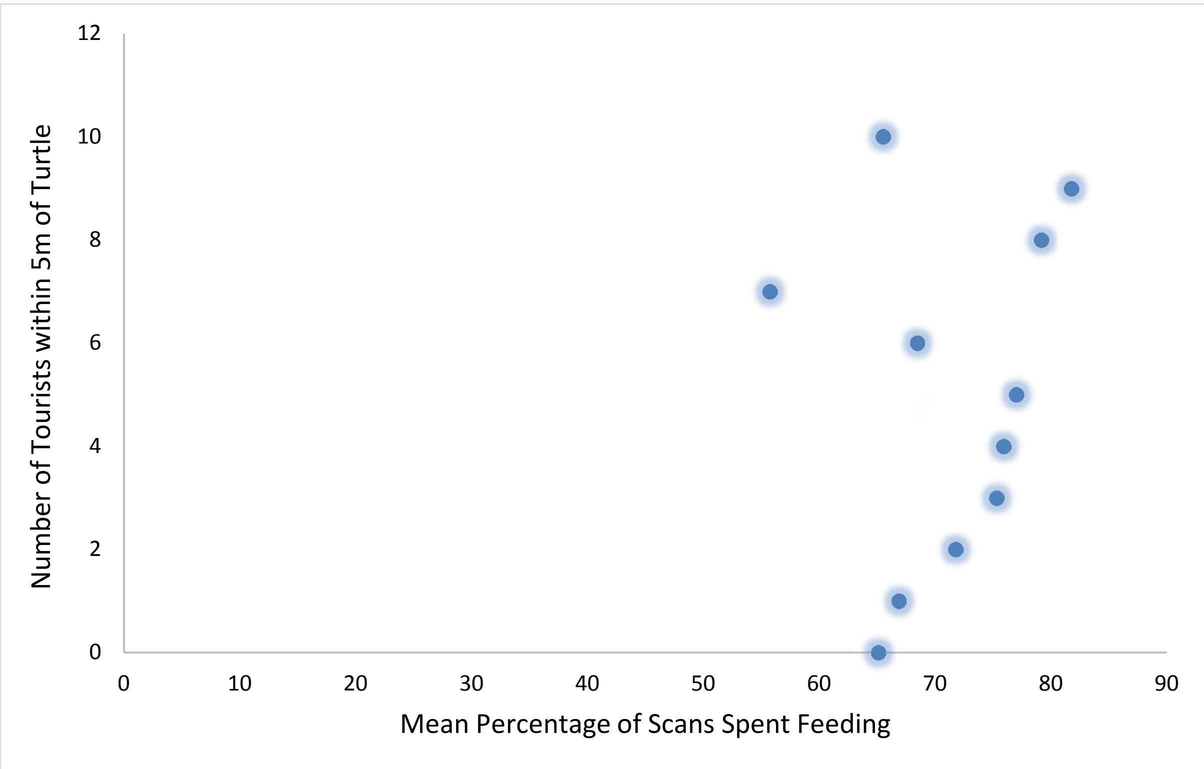


Figure 6: Correlation between the number of tourists present and the mean percentage of feeding scans recorded for the turtles

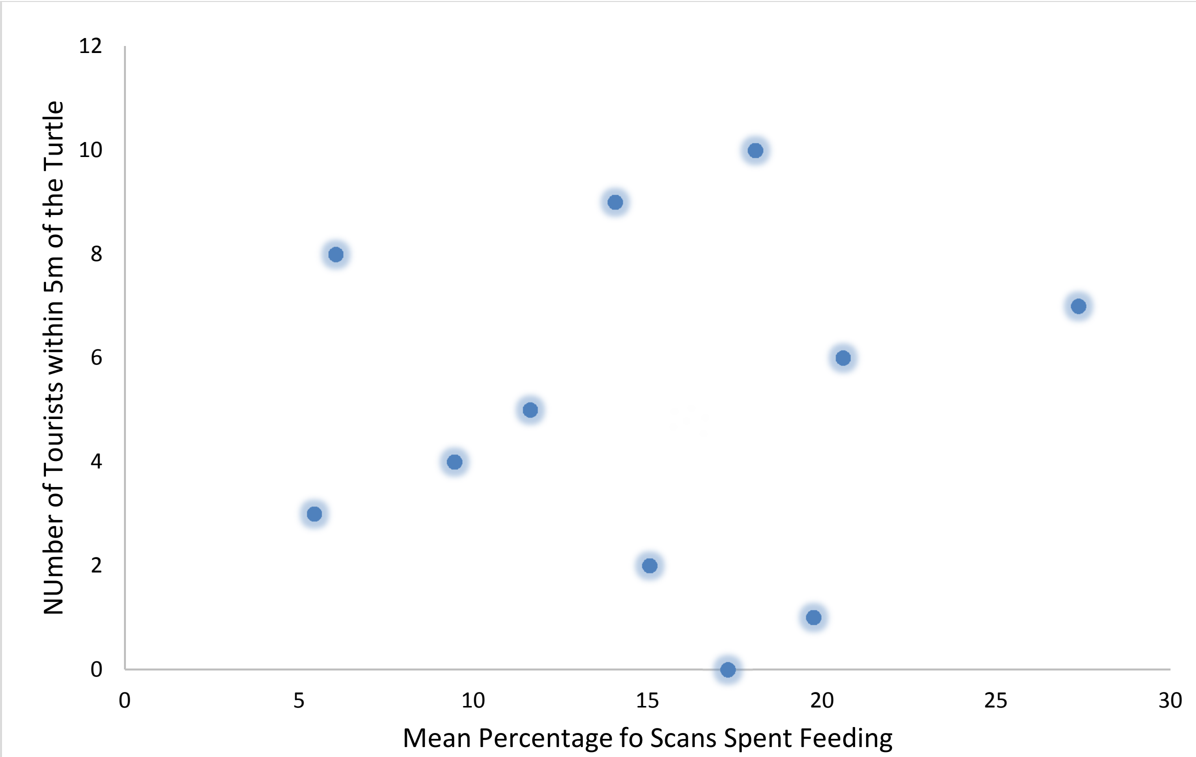


Figure 7: Correlation between the number of tourists present and the mean percentage of swimming scans recorded for the turtles

Turtle feeding preferences in relation to sea grass abundance

The activity budgets of immature green turtles in each of the two feeding zones (Zone S and Zone T) indicated a higher percentage of scan spent feeding when in Zone T (Figure 8) and this difference was confirmed statistically ($t_{(1, 29)} = 2.343$, $p = 0.029$). As suggested by their names, Zone T contained a greater percentage coverage of *Thallassia testudinum* sea grass whereas Zone S contained a greater percentage coverage of *Siryngodium filiforme/Halodule wrightii* ($F_{(1, 50)} = 12.320$, $p = 0.001$: Figure 9). General linear model analyses also confirmed that there was a trend towards a main effect of sea grass type with a greater percentage coverage of *Siryngodium filiforme/Halodule wrightii* irrespective of feeding zone ($F_{(1, 50)} = 3.727$, $p = 0.059$). There was no main effect of feeding zone indicating that percentage coverage of sea grass (irrespective of species) did not differ between the two feeding zones ($F_{(1, 50)} = 0.593$, $p = 0.445$). Based on the availability of each type of sea grass (mean percentage coverage), all 30 turtles spent significantly more time feeding on *Thallassia testudinum* sea grass that was expected based on its abundance ($X = 0$, $N = 30$, $p <0.001$).

Mean biomass of sea grasses showed a different pattern. There was no significant difference in the mean biomass of each sea grass type between the difference feeding zones ($F_{(1, 50)} = 0.502$, $p = 0.482$: Figure 10). There was no main effect of sea grass type indicating that when using biomass rather than percentage coverage there was no difference in the abundance of each type of sea grass ($F_{(1, 50)} = 1.650$, $p = 0.205$). There was also no main effect of feeding zone (indicated that sea grass biomass, irrespective of species was no different between the two feeding zones: $F_{(1, 50)} = 0.677$, $p = 0.415$).

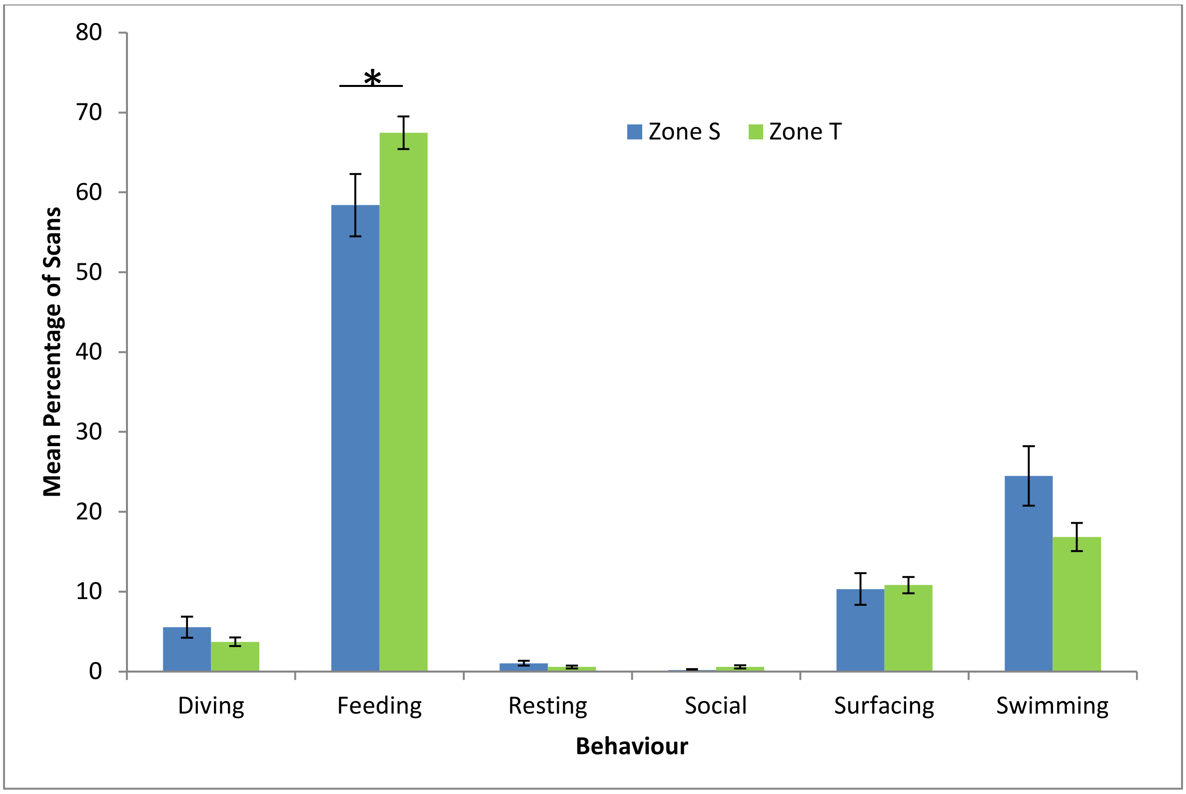


Figure 8: Mean (±SEM) activity budgets of immature green turtles in the two different feeding zones in Akumal Bay. * indicates significance of $p<0.05$.

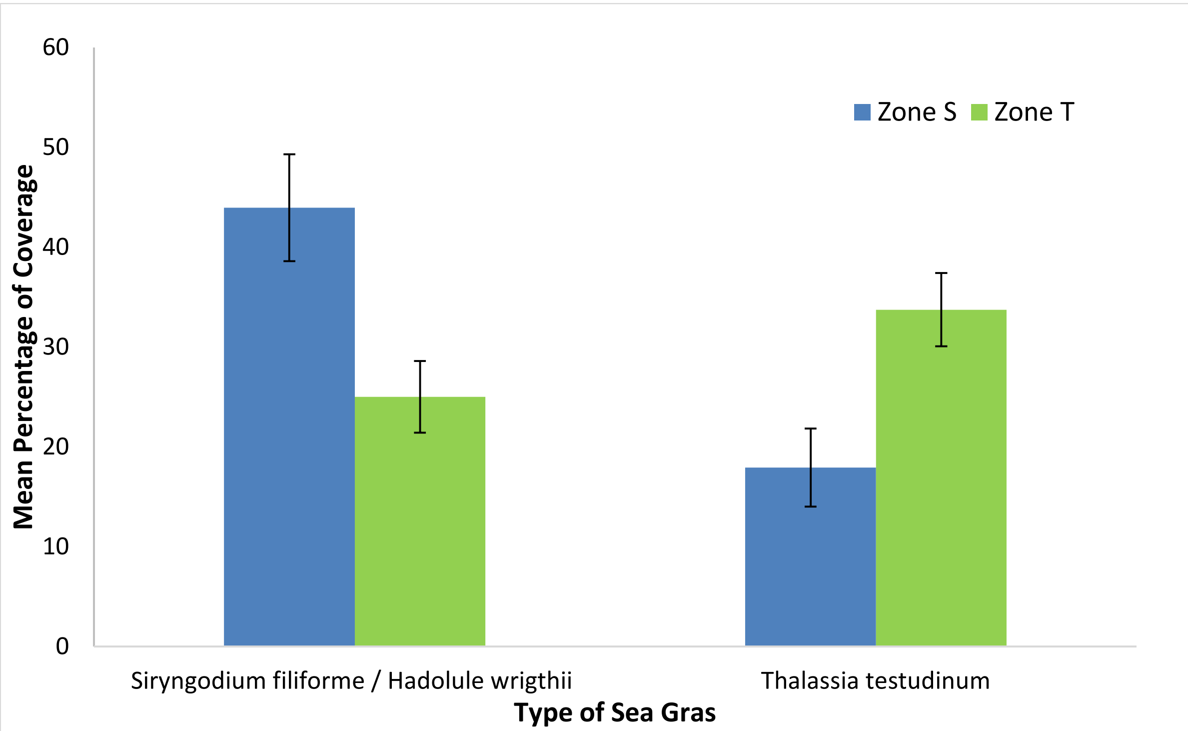


Figure 9: Mean (± SEM) percentage coverage of *Thallassia testudinum,* and *Siryngodium filiforme/Halodule wrightii* sea grasses in feeding zone S and T in Akumal Bay.

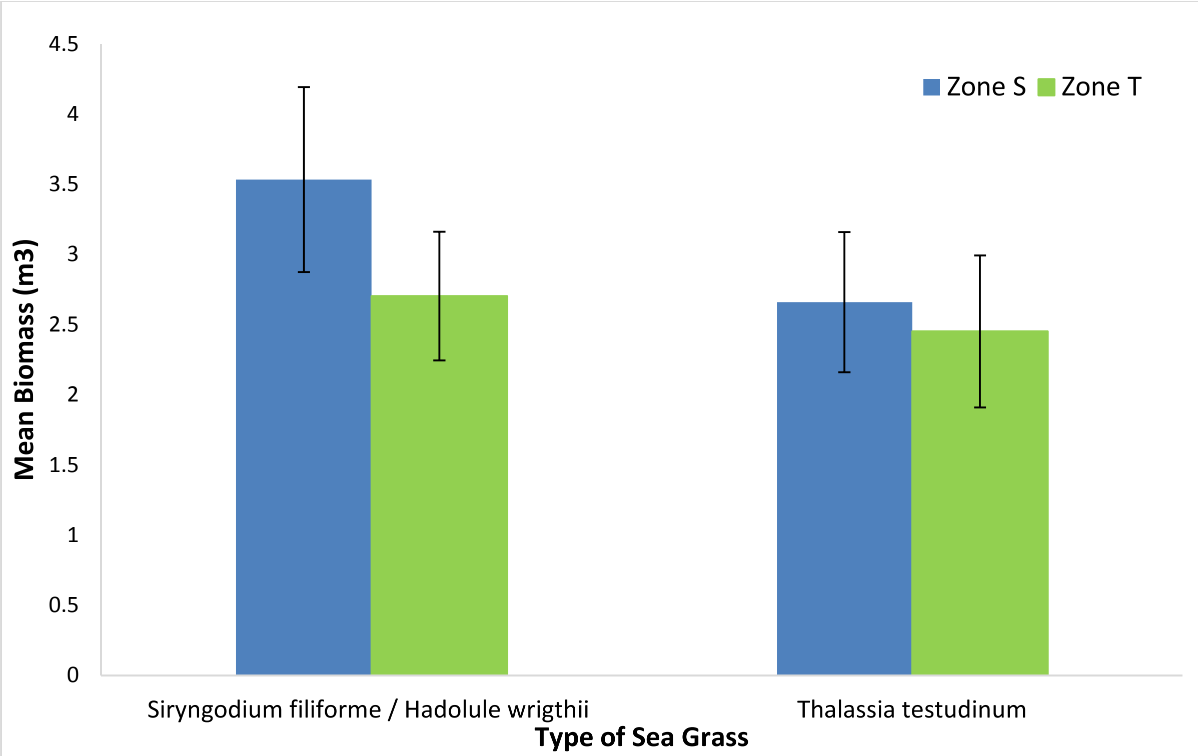


Figure 10: Mean (± SEM) biomass (m^3) of *Thallassia testudinum,* and *Siryngodium filiforme/Halodule wrightii* sea grasses in feeding zone S and T in Akumal Bay.

Discussion

Effect of tourism on immature green turtle behaviour in Akumal Bay

Contrary to prediction, swimming behaviour in the immature green turtles at Akumal Bay was unaffected by tourist presence and did not correlate with the number of tourists present. As predicted, there was a significant decrease in feeding behaviour when turtles where in the presence of tourists. Although statistically significant, the reduction in feeding time was only slight (71% of scans with no tourists present and 65% of scans when tourists were present) and was therefore unlikely to have a negative effect on the welfare of the turtles. Contrary to prediction, there was no correlation between the percentage of scans spent feeding and the number of tourists observing the turtles, suggesting that tourist numbers could increase exponentially with no impact on feeding behaviour, which is contrary to findings from other sea life (e.g. Constantine, 2001; Stensland & Bergren, 2007). However, the number of tourists within a 5m radius of the turtles was generally between 1-5 individuals and with some cases between 6-10 tourists and only a handful of cases where more than 10 tourists were present. The existing management plan for Akumal Bay that only permits small groups of tourists to view the turtles at any given time therefore appears to be successful at minimising impact on the turtles.

However, during the course of the study 37 cases of tourists breaking the 5m barrier to approach, photograph or attempt to touch the turtles were observed. These cases were only reported anecdotally and therefore could not be included in the analyses of this report, but in all cases the turtle responded with evasive behaviour in an attempt to escape from the tourists. On one occasion, a group of tourists actually attempted to use the turtle as a surfboard and only allowed the turtle to escape when the Operation Wallacea volunteers intervened (the problem was then reported to CEA, but by that time the tourists had fled from the beach). As attempts to interact with both captive and wild animals are reported to result in behavioural changes and increased anxiety (Stensland & Bergren, 2007; Fernandez et al., 2009; Marechal et al., 2011), it is extremely important to ensure that the tourists respect the rules and behave appropriately when observing the turtles. All tourist at Akumal are made aware of the rules prior to swimming with the turtles and CEA provide regular patrols of the bay along the beaches and in the water, but at very busy times it seems that it is not possible to ensure that all tourists abide by the rules. Consequently, it may be necessary to limit the number of people using the Bay at any given time to enable closer monitoring of tourist behaviour, but quantifiable data relating to the frequency and intensity of tourist interactions with turtles is required before further decisions can de made.

Overgrazing of sea grasses by immature green turtles in Akumal Bay

Behavioural data collection of the immature green turtles in Akumal Bay indicated that they have a strong preference for feeding on *Thallassia testudinum* despite the fact that *Siryngodium filiforme* and *Halodule wrightii* are generally more abundant. Based on mean percentage coverage, *Thallassia testudinum* appears to be the most abundant sea grass in feeding zone T, but as the turtles graze heavily on this species of sea grass the height of the grass is very low across both feeding zones and as a result, even in feeding zone T (that was named after *Thallassia testudinum*), the biomass of *Thallassia testudinum* was very low and was not more abundant that the biomass of *Siryngodium filiforme* and *Halodule wrightii*. Data from other populations of green turtles has reported that the turtles aggregate around specific feeding zones and continue to graze on their preferred foods until such a time as the carrying capacity of feeding zone is exceeded and the ecosystem crashes. When this happens, the turtles simple travel to a new feeding ground (Thomas et al., 2001; Arthur et al., 2008). If the sea grasses at Akumal Bay are not carefully managed, it is therefore likely that the resident immature green turtles will simply migrate to a new location, which would have disastrous consequences for local tourism.

As the turtles are not continuously grazing on the *Siryngodium filiforme* and *Halodule wrightii* grasses, the majority of these grasses how grown to be very long and these older grasses are more difficult to digest due to the high lignin content (Zieman et al, 1984). As with all grazing animals, turtles show a strong preferences for younger parts of the plants that have a higher nutritional content and are more easily digested (Bjorndal, 1980). Consequently, if the *Siryngodium filiforme* and *Halodule wrightii* were to be trimmed to replicate grazing and encourage new growth, it is possible that the turtles will spend more time feeding on these grasses, thus reducing the grazing pressure on the *Thallassia testudinum*.

Continuance of Study in 2014

In order to investigate the impact of tourist behaviour on immature green turtle behaviour, the study will be repeated in 2014 with the inclusion of invasive behaviour in the turtle ethogram and a new ethogram of tourist behaviour. Data will be collected while snorkelling in Akumal Bay using focal animal sampling with continuous recording (Altmann, 1974) whereby each student will follow a different individual turtle for a 20-minute period and will record their behaviour in real time based on pre-defined behavioural categories (Table 1). Continueous recording rather than instantaneous recording will be used to ensure that rare behaviours such as tourists interacting with turtles are included in the data set. The aim is to complete two 20-minute focal samples per hour with the remaining time spent locating and identifying each turtle. If the turtle is feeding, the type of sea grass will be recorded (*Thallassia testudinum, Siryngodium filiforme* and *Halodule wrightii*). The number of tourists within a 5 meter radius of the turtle will be recorded for each 1-minute interval. Any attempts of tourists to approach or interact with the turtle will be recording based on the pre-defined categories in Table 2. Feeding zone (T or S), will also be recorded for each 1-minute interval. If the turtle moves out of view for up to 3 minutes then their behaviour should be recorded as "out of view" and the data collection resumed as soon as the turtle is visible again. If the turtle remains out of view for longer than 3 minutes then the sample should be abandoned. Focal less that 5 minutes in duration should be abandoned, but anything longer than 5 minutes should be kept and the exact duration of the sample recorded.

Table 1: Ethogram of turtle behaviour

Behaviour	Code	Description
Feed	FE	Turtle masticates food while food is in its mouth or is foraging on prey items
Swim	SW	Turtle moves through the water at a steady pace in restively horizontal position
Rest	RE	Turtle is stationary and is not engaged in any other behaviour
Surface	SU	Turtle swims in a roughly vertical position towards the water surface to breathe
Dive	DI	Turtle swims quickly in a roughly vertical downward position
Evasive	EV	Turtle quickly changes direction and/or swims rapidly to avoid approaching human observer
Other	OT	All forms of behaviour not listed above, including all social interactions with one or more other turtles

Table 2: Ethogram of tourist behaviour

Behaviour	Code	Description
Acceptable	AC	Tourists maintain the 5m distance from the turtle, do not crowd around the turtle to prevent escape routes and do not attempt to interact with the turtle in any way
Approach	AP	Tourist moves within 5m of turtle, but does not attempt to interact
Photograph	PH	Tourist moves within 5m of turtle and attempts to photograph the turtle at close range
Touch	TO	Tourist physically touches the turtle
Crowd	CR	Two or more tourists move around the turtles in such a way that they block its travel path and potential escape routes. This behaviour can occur even if the 5m distance barrier is maintained

As data from 2013 indicates a clear preference for feeding on *Thallassia testudinum* grass, the study will be repeated in 2014 to determine in this preference persists. Provided that the relevant permits can be obtained, there is the option of trimming the *Siryngodium filiforme* and *Halodule wrightii* in designated areas the encourage new growth and determine if these nutritious young shoots can encourage the turtles to spend a greater proportion of time feeding on these sea grasses as opposed to *Thallassia testudinum.* To do this, each of the two feeding zones (S and T) will be divided into two separate areas of equal size: "trimmed" and "non-trimmed". *Siryngodium filiforme* and *Halodule wrightii* grasses in the "trimmed" areas will be clipped to a height of 5cm in order to encourage new growth. Trimming will occur prior to behavioural data collection to allow time for new shoots to grow before assessing turtle feeding preferences. The percentage of time each turtle spent feeding on *Siryngodium filiforme* and *Halodule wrightii* in trimmed and non-trimmed areas can then be investigated via behavioural observations. To asses any changes to *Thallassia testudinum* as a results of a shift in turtle grazing patterns, 15 quadrats, each 1m^2, with 20cm sub-division (i.e. 25 small squares inside the quadrat) will be randomly placed in the "trimmed" and non-trimmed" areas of the two feeding zones (60 quadrats in total). In each quadrat, the number of small squares that are covered by each type of sea grass or bare sand will be recorded. In addition, a graduated touch pole will be used to assess the height of the sea grass in each small square.

References

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227-267.

Arthur, K.E., Boyle, M.C. & Limpus, C.J. 2008. Ontogenetic changes in diet and habitat use in green sea turtle (*Chelonia mydas*) life history. *Marine Ecology Process Series* 362: 303-311.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J., Flajerty, C., Krutzen, M. 2006. Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology* 20: 1719-1798.

Bjorndal, K. A. 1980. Nutrition and grazing behaviour of the green turtle Chelonia mydas. *Marine Biology*. 56: 147-154.

Carlstead, K. & Shepherdson, D. 2000. Alleviating stress in zoo animals with environmental enrichment. In (G.P. Moberg & J.A. Mench Eds). *The Biology of Animal Stress: Principles and Implications for Animal Welfare.* Oxon: CABI Publishing

Constantine, R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus)* due to long-term exposure to swim-with-dolphin tourism. *Marine Mammal Science* 17: 689-702

Dawes, C. J., Bird. K., Durako, M., Goddard, R., Hoffman, W. & McIntosh, R. 1979. Chemical fluctuations due to seasonal and cropping effects on an algal-seagrass community. *Aquatic. Botany.* 6: 79-86

Detling, J.K. 1998. Mammalian herbivores: ecosystem-level effects in two grassland national parks. *Wildlife Society Bulletin*. 26: 438-448.

Fernandez, E. J., Tamborski, M. A., Pickens, S. R. & Timberlake, W. 2009. Animal-visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science* 120: 1-8.

Fritz, H. & Duncan, P. 1994. On the carrying capacity for large ungulates of African savanna ecosystems. *Proceedings of the Royal Society of London B*: 256: 77-82.

Heithaus, M.R., McLash, J.J., Frid, A. & Dill, L.M. 2002. Novel insights into green sea turtle behaviour using animal-borne video cameras. *Journal of the Marine Biology Association U.K.* 82: 1049-1050.

Hosey, G, Melfi, V & Pankhurst, S. 2013. *Zoo Animals: Behaviour, Management and Welfare (2nd Edition*). Oxford: Oxford University Press.

Karsten, B., Linke, K., Busch, M., Matthes, I., van der Woude, S. E. 2005. Impact of different groups of swimmers on dolphins in swim-with-the-dolphin programs in two settings. *Anthrozoos: A Multidisciplinary Journal of the Interactions of People & Animals* 18: 409-429.

Lopez-Mendilaharsu, M., Gardner, S.C., Seminoff, J.A. & Riosmena-Rodriguez, R. 2005. Identifying critical foraging habitats of the green turtle (*Chelonia mydas*) along the Pacific coast of the Baja California peninsula, Mexico. *Aquatic Conservation: Marine & Freshwater Ecosystems* 15: 259–269.

Reynolds, P. C. & Braithwaite, D., 2001. Towards a conceptual framework for wildlife tourism. *Tourism Management* 22: 31-42.

Stenslend, E & Berggren P. 2007. Behavioural changes in female Indo-Pacific bottlenose dolphins in response to boat-based tourism. *Marine Ecology Process Series* 332: 225-234.

Thomas, J., Aznar, F.J. & Raga, J.A. 2001. Feeding ecology of the loggerhead turtle *Caretta caretta* in the western Mediterranean. *Journal of the Zoological Society of London* 255: 525-532.

Tisdell, C. & Wilson, C., 2002. Ecotourism for the survival of sea turtles and other wildlife. *Biodiversity and Conservation* 11: 1521-1538.

Wilson, C. & Tisdell, C., 2001. Sea turtles as a non-consumptive tourism resource especially in Australia. *Tourism Management* 22: 279-288.

Appendix A: Immature Green Turtle IDs

Turtle Name	Turtle Tag	Turtle Description	Photos
Acan	?? 621	hexagonal shape on back of head, and distinctive unique shape a top of back	63, 499, 500
Akna	MXW 0979	long thin head, lots of black markings on head	743, 744, 745
Apollo	?? 531	Dark circle on back of head with white line running through it	141, 372, 373, 559, 560, 561, 792 793
Aphrodite		Top scale shaped like arrow	242, 243
Athena	XD 898	Triangle shape on shell	511, 512, 513, 579, 580, 581
Asteria	XT 045	White patches on scales on back of head and one small black spot on middle of back of head	100, 101, 102, 181, 182, 183, 186, 187, 188, 276, 277, 278, 281, 283, 291, 292, 293, 376, 377, 584, 765, 766, 767
Bahlam		Bottom middle scale is rectangular and second middle scale is damaged	36, 37, 38, 128, 129, 287, 288, 289, 415, 416, 417, 422, 423, 424, 458, 459, 460, 477, 478, 479, 483, 484, 485, 488, 489, 492, 493, 494, 631, 632, 633, 711, 712
Bacab	XD 900	Top part of head completely black	418, 420, 421, 419, 555, 694, 695, 737, 771, 800, 801, 802
Baldur	?? 869	Very top of head black, elongated pentagonal shape in middle	125, 126, 480, 481, 482, 590, 591, 592, 809, 810, 811
Brahma	?? 867	Pale colouring all over, very pale head with one black shape in middle	244, 245, 246, 617, 618
Chac		Bottom scale shaped like diamond w/ tracker	61, 62, 256, 257, 330, 331, 332, 453, 454, 509, 533, 534, 535, 587, 588, 589, 763, 764, 774, 775
Coyopa	XD 875	No black markings on head, solid brown colouring on head and body, pointed edges to markings on middle of back	151, 152, 153, 169, 170, 171, 192, 193, 194, 210, 211, 305, 306, 360, 361, 362, 545, 546, 573, 574, 575, 582, 583, 602, 603, 604, 642, 643, 644, 653, 654, 655, 665, 666, 667
Exchuah	XT 061	Flecks of white around edges of markings on back, irregular shaped scales on head, small black spots in middle pentagon shape on head	381, 382, 383, 409, 410, 411
Freya	?? ??5	White flecks all over back, elongated black hexagon with curved edges on head	18, 19, 20
Ganesh	XD 815	Top of head black, small black pentagon on head with back colouring stretching into scale below in an irregular pattern.	55, 56
Hades	XD 897	White flecks on head, but no black markings	593, 594, 595
Hera	HX 625	Tracker	
Hermes	XD 892	Matching diagonal white lines (pointing inwards) at base of head	313, 314, 315, 505, 506, 507, 746, 747, 748
Inti	?? 889	Middle scales on back almost identical in shape, matching black markings on either side of head, bottom two scales on head clear	94, 95, 96
Itzmana	?? 890	Rounded head, perfectly symmetrical scales, no black markings on head	24, 25, 91, 92, 93, 268, 269, 270, 576, 577, 578, 599, 600, 601, 622, 623, 624, 639, 640, 641, 675, 676, 677, 720, 721, 722
Ixchel		Five scales on right side of back, no black markings on head	787, 788
Kinich	?? 894	Similar markings on head to Lockjaw, but middle scale a heptagon	110, 111, 112, 204, 205, 206

Kon	?? ??0	Unique shape on middle of head with two almost circular scales either side of it	22, 23, 157, 158, 159, 166, 167, 168, 249, 250, 251, 363, 364, 365, 425, 426, 427, 570, 571, 572, 686, 687
Kronos	MXW 0976	Has satelite tag and brand new ID tag	406, 407, 408
Kukulkan	XD 893	Two tags on left fin, small middle hexagon on head and black markings round the edge	108, 109, 195, 196, 322, 323, 352, 353, 354, 412, 413, 414, 556, 557, 558, 628, 629, 630, 645, 646, 647, 806, 807, 808
Lakshmi		Small, has black marking on head to the left side that looks like a square	163, 164, 165, 728, 729
Loki		Middle pentagon on head has white line running through it with one black spot on the left side and a black line on the right. Middle scale on back of head had rounded bottom	132, 133, 230, 231, 232, 345, 346, 431, 432, 433, 474, 475, 476, 525, 526, 527, 596, 597, 598, 609, 610, 662, 663, 664, 690, 691, 740, 741, 742, 791
Lodur	?? ??2	No black markings on head, all scales wierdly shaped	106, 107
Magni	XD 857	Extra scale at bottom of head on right hand side	714, 715, 716
Mimir		White barnacle like mark between second middle scale and right scale	148, 149, 150, 299, 300, 501, 562, 563, 564
Mizheekay	?? 896	White spot on middle scale at top of back	137, 138, 265, 266, 267, 461, 462, 463, 466, 467, 468, 550, 551, 552, 567, 568, 569, 749, 750, 751
Nerites	?? 618	Black markings on head that look like wings	154, 155, 156, 355, 356, 357, 636, 637, 638
Oceanus	?H 625	White and dark brown stripes on pale brown back	79, 80, 81
Odin	?? 826	Elongated and symetrical pentagon on head with white that separates the scales immediately above extending into the top section of this pentagon	768, 769, 770
Pacha	HX 608	No small middle pentagon shape on head as found in the other turtles. Wiggly white line dividing the two scales on top of head	384, 385, 386
Parvati	XD 878		
Perses	?? 562	Two symetrical black shapes on either side of scales on top of head. Middle pentagon on head has black shape in it, and is eloganted with almost curved bottom	4, 5, 6, 45, 46, 47, 67, 68, 87, 88, 89, 175, 176, 177, 189, 190, 191, 214, 215, 216, 217, 218, 219, 301, 302, 446, 447, 448, 438, 439, 517, 518, 519, 520, 521, 522, 585, 625, 626, 627, 670, 671, 672, 692, 693, 705, 706, 707, 732, 733, 734, 784, 785, 786
Ran		Extra scale on bottom right of head, and large hexagon shape in middle of head has a pointed bottom. Has white spot on back on the middle scale, second from the top	75, 76, 184, 185, 222, 223, 290, 297, 298, 358, 359, 543, 544, 634, 635, 754, 755
Selene	MXW 0916	No black markings on head, middle pentagon has almost curved top. Has satellite tracker	327, 328, 329
Shiva	XD 899	Symmetrical scales on smooth brown head. Middle pentagon has black shading to the top and a line of back under the bottom line of the scale	103, 104, 105, 284, 285, 286, 514, 515, 516, 536, 537, 673, 674, 756, 757, 758, 803, 804, 805
Themis	XD 873	Middle pentagon on head half filled with black, scales above this have lines of black running through them	1, 2, 3, 15, 16, 17, 39, 40, 41, 85, 86, 97, 98, 99, 236, 237, 238, 252, 253, 259, 260, 261, 469, 470, 471, 678, 679, 680, 688, 689, 708, 709, 710
Thor	XD 856	Pale coloured head with no black markings. Whire vertical line on middle pentagon on head that separates it in half	387, 388, 389
Triton	XD 891	Tiny extra triangle shape in middle of the base of the head. Pale coloured head with no black markings	42 ,43, 44, 48, 49, 50, 53, 54, 72, 73, 74, 160, 161, 162, 224, 225, 336, 337, 338, 318, 319, 320, 369, 370, 371,

			443, 444, 445, 486, 487, 648, 649, 650, 794, 795, 796
Vali	?? ??9	Pentagon on head notably wider at the top than the bottom	656, 657, 658
Vishnu	MXW 0978	Very light brown all over, symmetrical scales on head with black shape in pentagon on back of head. Has satellite tracker	702, 703, 704
Zeus	PR 618	Broad head. Middle hexagon on had wider than it is longer. Dark brown colouring on body	347, 348, 349, 530, 531, 532