Feeding Behaviour in Loggerhead Sea Turtles (*Caretta caretta*)

Collection of Movement Data Representative of Feeding Events

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With the different threats sea turtles are currently facing, such as habitat reduction and pollution, increase of fishing and harvesting of aquatic resources by Humans, or invasive species, it is important to learn as much as possible about their biology and behaviour in order to ensure the success of conservation programs. In this study, loggerhead sea turtles (*Caretta caretta*) feeding behaviour duration as well as energy expenditure approximation during a feeding event were tested and compared using two different types of food: green shore crabs (*Carcinus maenas*) or Japanese clam (*Ruditapes philippinarum*) or Venus clams (*Chamelea gallina*). The data show that the turtles took longer to approach the crabs but took more time to eat the clams. However, comparison of energy expenditure values for the feeding phase showed no significant differences. The turtles were observed to eat the clams’ shell as well as their meat. These shells are rich in calcium, which is one possible explanation for this behaviour. This study shows that data loggers represent a viable tool for studying the behaviours of marine animals.

**Nyttelord**
Clams, Crabs, Data logger, Calcium, Loggerhead, VeDBA, feeding behaviour
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1 Abstract

With the different threats sea turtles are currently facing, such as habitat reduction and pollution, increase of fishing and harvesting of aquatic resources by Humans, or invasive species, it is important to learn as much as possible about their biology and behaviour in order to ensure the success of conservation programs. In this study, loggerhead sea turtles (*Caretta caretta*) feeding behaviour duration as well as energy expenditure approximation during a feeding event were tested and compared using two different types of food: green shore crabs (*Carcinus maenas*) or Japanese clam (*Ruditapes philipinarum*) or Venus clams (*Chamelea gallina*). The data show that the turtles took longer to approach the crabs but took more time to eat the clams. However, comparison of energy expenditure values for the feeding phase showed no significant differences. The turtles were observed to eat the clams’ shell as well as their meat. These shells are rich in calcium, which is one possible explanation for this behaviour. This study shows that data loggers represent a viable tool for studying the behaviours of marine animals.

Keywords: Clams, Crabs, Data logger, Calcium, Loggerhead, VeDBA, feeding behaviour

2 Introduction

The loggerhead sea turtle (*Caretta caretta*) is found in many different waters all around the world, from the Japanese coast to the southern Caribbean Sea, and is the most common turtle in the Mediterranean Sea. Despite a wide distribution, the global population has declined by 80-86% in the last 20 years (Lewison et al. 2004) and is now classified as “vulnerable” on the IUCN Red List, with a severely fragmented population (Casale and Tucker 2017). Indeed, like many other marine species (mammals, fishes and reptiles), loggerheads face diverse threats, such as collision with boats and ingestion of debris (mainly plastic). These threats can impact survival and reproduction (Darmon et al. 2016). Loggerhead sea turtles are also one of the two marine turtle species, together with Leatherbacks (*Dermochelys coricea*), that are most affected by pelagic longline fishing, where they are often caught as bycatch (Lewison et al. 2004). This phenomenon is observed in many places, including in the Mediterranean Sea. With regards to its population decline, and in order to enhance the success of conservation programs for this species, it appears important to learn as much as possible about loggerhead biology and behaviour.

Ample data and information about loggerheads have already been collected and reported, including their migration habits, development and reproduction, but less is known
about their feeding behaviour (McClellan and Read 2007). *C. caretta* is a species that mostly feeds on crabs, bivalves, gastropods, fishes, urchins, sponges and jellyfish (Tomas et al. 2006) using its strong beak to break the shell of its prey, and differences in the diet can be observed between different populations (Parker et al. 2003). However, considering its large variety of prey, one could imagine different feeding behaviours related to the type of prey on which it is feeding. The study of feeding behavioural parameters could allow us to assess and understand what governs foraging success and also how a type of prey could influence a feeding event as suggested by Hochscheid et al. (2004). For example, *C. caretta* have already been observed using their front flippers when eating jellyfish or small squid. However, sea turtles being marine animals, it is sometime tricky to observe their behaviour properly in their natural habitat. The use of data loggers placed on the carapace of the turtle might then represent a convenient way of collecting behavioural data, such as accelerometry. Accelerometry data have already been used to study behaviours of penguins and sea lions (Fahlman et al. 2008, Qasem et al. 2012) and could represent a viable and convenient option for sea turtles.

In this study, the idea was to see if data loggers, combined with video recording, could be used to obtain and describe movement data that would be specific to the type of prey a turtle is feeding on and, by doing so, establishing a “prey signature”. Obtaining this kind of data could allow us to understand *C. caretta* feeding habits more precisely and how important is a type of prey compare to another one in its diet. In the long term we could then maybe establish how the reduction of crabs, urchins or jellyfish, for example, can influence *C. caretta* survivability depending on their prevalence in the turtles’ diet. We could also examine how *C. caretta*’s diet evolves through life by comparing young individuals’ feeding habits to those of older individuals. And finally, it could also help to see how a young turtle is learning about foraging behaviour, especially since they do not have any source of model from a parent. To accomplish these goals loggerhead sea turtles under human care were here monitored with data loggers mounted to their heads and carapaces to collect preliminary data comparing feeding behaviour between different types of food. This study also serves to validate the use of carapace- and head mounted data loggers for future studies on marine turtle feeding behaviours.
3 Materials and methods

3.1 Facility and animal acquisition

The experiments were conducted in the ARCA del Mar (Area de Recuperacion y Conservacion de Animales del Mar) facility at the Oceanografic, Valencia (Spain), which has a permit from the Valencian Regional Government for sea turtle rehabilitation (both bycatch and stranded) and post-mortem examination. The experiments were carried out, between the 30th of May until the 16th of August 2018.

A total of 11 loggerhead sea turtles were included in the experiments and all animals were brought to ARCA del Mar by fishermen working along the Valencian coast of Spain. The turtles were brought to the rehabilitation facility either due to, fishery related injuries (Figure 1) or performing unusual behaviour, e.g. floating at the surface for a long period with moving flippers or its body, which is unusual for a sea turtle (Table 1, Appendix). The turtles were then rehabilitated in ARCA until they had recovered from their injuries and subsequently released back into the wild.

All the turtles present in ARCA del Mar were split between nine round, white, seawater tanks (Figure 2) of various sizes and temperatures (Table 2, Appendix). Eight of the tanks were found inside ARCA del Mar and one was located outside the building as an exhibit support for the park. The turtles were fed by the zookeepers or by veterinarians every morning, excluding the Wednesdays and weekends, with a mixture of squid, fish, vegetables (carrots, zucchini) put together in jelly to which was added nutrients and vitamins for the individuals that required it.

Figure 1: Example of carapace trauma (Turtle 408)

Figure 2: Tank A2, inside ARCA del Mar facility
3.2 Feeding experiment

The feeding experiments were performed directly in each turtle’s tank, except for the turtle in the outdoor exhibition tank, as this tank was too small and reflection from the sunlight impaired visibility from above the water surface. The turtle outside was brought to a tank inside the building for the duration of the experiment. The experiment was conducted over 15 days, for three turtles on each day, except for the last two days where only two turtles were tested. The whole experiment resulted in a total of 46 trials, with 11 different turtles tested within their presence time in ARCA del Mar.

The experiments were performed on Mondays and Thursdays, before the general feeding took place, in order ensure that the turtles where sufficiently hungry to eat the experimental food since they were not fed during on Wednesdays and weekends. At the very beginning of the experiment, on the Monday, the turtles were fed with live moon jellyfish, also known as common jellyfish (*Aurelia aurita*), coming directly from Oceanografic. However, after 18 trials, only four feeding events were recorded, all from the same individual (turtle 397), out of the three that were tested. To try to enhance the success of the experiment, the jellyfish where coloured orange by feeding them with plankton, so they would become more visible for the turtles. The trial was repeated for turtle 397 and two new turtles (the other previously tested had already been released). But still no feeding events were observed with the orange jellyfish. Because the turtles could only be accessed for a limited period of time before they were released in the wild, and in order to ensure collection of sufficient data, jellyfish, which are also part of *C. caretta*’s diet, were substituted for clams.

As a result, on Mondays, the turtles were given five live Japanese clams (*Ruditapes phillipinarum*) or Venus clams (*Chamelea gallina*) each, freshly purchased the same day of the experiment. The two species of clams were similar and could probably not be differentiated by the turtles. The choice of the clam species was dependant on availability at the fishmongers. We also tried to select the smallest clams, so the younger and smaller turtles would not have problems breaking the shell to eat the animal. On Thursdays, the turtles were presented with five live green shore crabs (*Carcinus maenas*) each, purchased at Decathlon Valencia, the evening before. Since the crabs were received by Decathlon every Tuesday or Wednesday morning, turtles couldn’t be tested with crabs on Mondays. The caloric value of each food type was determined by the science laboratory at Oceanografic using bomb calorimetry.
Before starting the feeding experiment, multi sensor archival tags were attached to both the head and the carapace of a turtle. These tags recorded data about tri-axial acceleration, tri-axial magnetic field intensity, depth and temperature. Two different types of pressure sensor (part of the tag) were used: Keller and simple. The Keller pressure sensor is a bigger and older version of the regular sensor. Both types of tags (head and body) were powered by a 3.7-V lithium battery and housed in a plastic box and could record 2 GB of data with a 20 Hz sampling frequency and 40 Hz for the Keller pressure sensor. The head tag plastic box was 2x1.3x4 cm, sealed with waterproof tape and placed in a small green balloon, tightly closed, to avoid contact between the circuit board and water. Two types of housing were used for the body tags: normal and large. The normal housing was 2.7x1x6.5 cm; the large housing was 3x1.8x8 cm (without the screws) and used with a Keller pressure sensor. Therefore, the Keller tag and its bigger housing were used only with the biggest turtles. Both body tags housings were sealed with the same waterproofed tap as for the head tag. The loggers were then fixed on the turtles’ head and carapace with epoxy (Subcoat S, comp B, Underwater filler-Veneziani and Subcoat S, comp A, Underwater filler-Veneziani). The head tag was fixed on the middle of the turtle’s head and the same was used for the three turtles, while the body tag, one for each turtle, was fixed on the upper part of the carapace (Figure 4). Once the tags were both fixed on the turtle, the animal was put back in its tank. Ten minutes minimum were then given to the turtle to allow it to recover from the stress of handling. When the ten minutes had passed, we would start with the first crab or clam. One was given to the turtle every five minutes for a total trial duration of 25 min, which was judged to be sufficiently long for the turtle to become aware of the food. The trial would always be 25 minutes, no matter if the turtle ate within this time period or not. If the turtle did not eat...
everything by the end of the experiment, the remaining clams or crabs were removed from its tank. At the end of the trial, the head tag was removed and used for the next turtle while the body tag would usually remain on the individual for the collection of complementary data regarding a separate project, for approximately three or four days, until its battery was depleted.

All the experiments in this study were approved by the Animal Care and Welfare Committee at the aquarium.

3.3 Statistical analysis

3.3.1 Approach phase and feeding phase duration

For each individual turtle (N=11), mean approach and feeding duration were calculated from its feeding events (from 2 to 22 feeding events per food per turtle), and these were used as the individual replicates in a Mann-Whitney U-test (approach phase duration) and an unpaired t-test (feeding phase duration) to compare mean duration between foods.

3.3.2 VeDBA

Because the loggers were recording data at 20Hz, each second of a feeding event had 20 VeDBA values, from which a mean VeDBA was calculated for each second of each feeding event. A mean was then calculated using all the data. From the feeding event means, a mean was calculated for each individual turtle (from 2 to 22 feeding events per food per turtle), for each type of food. These were used as the individual replicates in an unpaired t-test to compare mean VeDBA between foods. This was done with both head tag data and body tag data.
4 Results

4.1 Feeding behaviour observed from video

A total of 142 feeding events were video recorded: 69 with clams and 73 with crabs. Attempts to video record the turtles’ behaviour under water were attempted but caused unwanted behaviour such as swimming away from or attempting to bite the camera. The head and jaw movements could not be accurately observed from video recordings above the water, and only the results from the tag were used for comparison. Therefore, only the approach and feeding phases durations were compared between the two types of food.

I defined the approach phase from the moment the turtle would start swimming in the direction of the food to the first successful bite. As the crabs were alive, they often tried to escape, and the first bite attempt was therefore not always successful. In those cases, the approach time was

![Approach phase duration for Clams and Crabs](image)

*Figure 5: Comparison of the average approach time (s) between the two types of food (clams and crabs) for all tested individuals (means ± standard error)*

![Feeding phase duration for Clams and Crabs](image)

**Figure 6: Comparison of the average feeding phase duration between the two types of food (Clams and Crabs) for all tested individuals (means ± standard error)**
extended until the turtle successfully grabbed the crabs. The average approach time (Fig. 5) between crabs and clams were significantly different (Mann-Whitney U-test: U=1485.5; p=0.016).

The feeding phase was defined as starting from the first successful bite to the moment the turtle would swim away from the zone where the food was, and jaw movements stopped. The feeding duration was 104% longer for a clam compared with a crab (Unpaired t-test: t=3.46 df=13; p=0.004; Fig. 6).

4.2 Energy expenditure and intake
Vectorial body dynamic acceleration (VeDBA) was measured from the multi sensor archival tags placed on the turtles back and was used to qualitatively assess the energy expenditure during the feeding phase. There were no differences in average VeDBA for the head (Unpaired t-test: t=0.29; df=16; p=0.778) or body tags (Unpaired t-test: t=0.35; df=16; p=0.729) between feeding on clams or crabs (Figs. 7a and b).

![Average head-tag VeDBA](image_a)

![Average body-tags VeDBA](image_b)

**Figure 7:** Average VeDBA obtained from the head-tags (a) and the body-tags (b) for both types of food, for every individual (means ± standard error)
The caloric content of 1kg of clams was 189 kcal, and an average clam, with an average weight of 22g, would contain 1.352 kcal. The caloric value of kg of crabs was 527 kcal, and one crab, with an average weight of 27.78g, would be 2.214 kcal (Figure 9). For a clam, 1352 calories took 47s to consume, resulting in a calorie intake rate of 29 calories per second versus 96 calories per second for a crab.

![Calories intake from one Clam or one Crab](image)

**Figure 9: Calories intake for one clam or one crab respectively**

5 Discussion

Recent studies have shown that animal-borne tags associated with video recording can be useful tools to report, document and understand the behaviours of animals, both captive and wild (Fahlman et al, 2008; Wilson, 2003). This is particularly true of marine animals such as sea turtles, which are harder to observe than terrestrial animals since they are hidden underneath the water surface. Thus, animal-borne tags represent an opportunity to learn more about sea turtle behaviours, including the loggerhead sea turtle (*Caretta caretta*). Studying *C. caretta* in human care would allow us to characterize specific behaviours that could be recognized and categorized by combining video observations and accelerometry data, which helps validate interpretation of data recorded from individuals in the wild.

In the present study, I examined if loggerhead sea turtles held under human care would exhibit different feeding behaviours depending on the type of food and if those potential differences could then be observed on accelerometry data, combined with video recording.
5.1 Sea turtles did not want to eat jellyfish

The original plan was to compare feeding behaviour between jellyfish and crabs, but as mentioned in the methods, jellyfish had to be substituted with clams. It is unclear why the turtles were not interested in the jellyfish. Indeed, we know that sea turtles, including C. caretta commonly eat jellyfish. However, the jellyfish species used in the present study, Aurelia aurita, is not the usual species that C. caretta has been observed eating, which is the pelagic jellyfish (Pelagia noctiluca) (Bolten et al. 1995, Plotkin et al. 1993). I also observed some individuals attempting to bite the jellyfish’s shadow at the bottom of the tank. This suggests the turtles did not actually see the jellyfish, which were usually staying at the surface rather than swimming in the water column. However, it has been shown in different studies that sea turtles, including loggerheads, actually have good vision. Loggerheads’ eyes have high spatial resolution and are well adapted to dim light which make them particularly good at foraging for slow-moving benthic prey in shallow water (Bartol et al. 2006, Bartol et al. 2002).

Because the tanks were completely white and A. aurita are difficult to see due to their translucency, it is possible that the contrast between the water and the jellyfish was not sufficient for the turtles to perceive their prey. In an effort to increase contrast, the jellyfish were fed plankton prior to subsequent experiments, which made them orange in appearance, which is within the wavelength turtles can see (Tucker et al. 1998). However, despite this coloration, the turtles still did not show any interest towards the jellyfish. This lack of interest could also be explained by the poor nutritive value of the jellyfish, and since the turtles were not especially hungry, being fed regularly during their time at Oceanografic, they may have been of too little interest for the tested animals. It would have been interesting, however, to experiment with another species of jellyfish and maybe in a coloured tank to increase the contrast.

5.2 Sea turtles display different feeding behaviours duration when eating clams or crabs

Recorded videos were used to observe and time directly observable feeding behaviours from above the water surface. It was not possible to directly film from underwater for a more precise characterization of feeding behaviour, especially through the observation of beak movements, but as any attempt to immerse the camera underwater would result in the turtle swimming away from the area and abandoning the food, or sometimes even trying to bite the camera.
The approach phase was always the first observed behaviour of any feeding event. When timed and compared, the approach phase was significantly longer when eating crabs than it was for clams. This difference in approach time can probably be explained by the fact that the crabs were able to move away from the turtle. This observation also implies that the turtles would potentially spend more energy in order to catch a crab than a clam.

In a previous study, Narazaki et al. (2013), showed that wild loggerhead sea turtles would decelerate shortly before reaching their prey. So, based on the assumption that turtles are showing a deceleration before eating, and that this deceleration duration is probably related to the duration of the approach phase, it could then be possible to identify a potential feeding event and guess the type of food they’re currently chasing, based on the duration of the deceleration period.

The length of the feeding phase was also compared between the two types of food, and the turtles spent significantly more time eating clams than crabs (feeding phase was twice as long for a clam than for a crab). This difference could be partly explained by the fact that the clams’ shells were sometimes hard to break for the turtles, especially the youngest and smallest turtles. But more importantly, this difference could be explained by the fact that the turtles would usually take the time to eat the small remaining pieces of the shell that fell to the bottom of their tank. This extra effort may be explained by the micro nutritive value of the shell (see section 5.3).

5.3 Compared energy expenditure and intake

Any kind of movement performed by an organism requires energy from the body. It is therefore possible to approximate the energy expenditure of an animal performing a specific movement or behaviour, such as foraging, by using body acceleration measured using a logger placed on the animal’s body as a proxy for energy expenditure. These kinds of studies have already been performed on penguins, humans, and sea lions for example (Fahlman et al. 2008, Wilson 2003, Qasem et al. 2012). The vectorial body dynamic acceleration (VeDBA), which was used in the present study, is one way of approximating the energy an organism is spending while moving (Wilson, 2003). VeDBA was compared between turtles feeding on clams and turtles feeding on crabs.

For both tags, on the head and on the carapace, mean VeDBA did not differ significantly between crabs and clams during the feeding phase (Figure 8-a-b). This suggests
that the turtles used the same amount of energy while they were feeding on a clam or on a crab, despite the fact that they spent more time eating clams.

However, when comparing the energy (in Kcal) a turtle would gain from a single crab or a single clam I found that turtles would gain more energy by eating a crab than a clam (shell included) if we only consider its higher calorific value. However, since clams are static prey, which is not the case for crabs, they then represent an easily accessible source of energy for an animal such as a turtle. A turtle would have to chase a crab in order to eat it, thereby increasing its energy expenditure (lowering its net energy gain from the food) in comparison to foraging on clams or any other kind of static or slow-moving prey.

Looking beyond energy expenditure and calorie intake, turtles could have further reason for eating clams despite their lower calorific value. Indeed, as mentioned before, the turtles in this experiment were observed eating the remaining pieces of the clams’ shells that fell to the bottom of their tank. Clams’ shells, like those of other molluscs, are rich in calcium; they are even used in the egg industry as a calcium supplement for laying hens (Finkelstein et al. 2010). Furthermore, we know that turtles’ shells, in addition of being a suit of armour to protect their body, also serves as a reservoir for minerals essential to their metabolism, such as magnesium, phosphate, sodium and calcium, which serve to buffer the blood from acid-base disturbances when the turtles are diving (Jackson et al. 2007).

Jackson (1982) demonstrated that the buffering capacity of the shell can be essential for freshwater turtles and improves their capacity to resist the development of anoxia during long dives. Indeed, during a long-term submergence, the acid homeostasis of the body is threatened, mostly by an increased concentration of lactic acid in the plasma which can lead to metabolic acidosis. When placed in a prolonged anoxic environment, *Chrysemys picta bellii* (the painted turtle, a freshwater turtle) were found to have elevated concentrations of potassium, calcium and magnesium in their plasma, along with decrease concentrations of chlorine and bicarbonate. Magnesium and calcium, along with carbonate, help the turtle to regulate the acid-base balance of its body during an expended exposure to an anoxic environment, by binding to the lactate and buffering it into the shell (Jackson 1997, Jackson et al. 1982). Ingesting calcium could then be necessary for a turtle spending most of its time in the water, in order to avoid metabolic acidosis.

However, it is not necessarily correct to assume such metabolic similarities between sea turtles and freshwater turtles. Indeed, although freshwater turtles, such as *C. picta*), can spend up to several months under water (from 3 to 6 months), in an anaerobic environment
(Ultsch 1989, Ultsch and Jackson 1982, Jackson 2002), this kind of behaviour has never been reported in sea turtles. It was thought in the early 1970’s that maybe the sea turtles were hibernating just like the freshwater turtles, based on observations made by indigenous peoples and fishermen from Mexico. However, more recent observations contradict this notion. The longest dive ever recorded in sea turtles was done by loggerheads who were observed diving for up to seven hours while overwintering in the Mediterranean Sea (Hochscheid et al. 2005). On a more regular basis loggerheads have been observed diving up to three hours (Hochscheid et al. 2007), while leatherback sea turtles (Dermochelys coriacea) have been observed diving for approximately 10min before surfacing again during a foraging behaviour (Scott et al. 1989). Based on the duration of a sea turtle dive, which is believed to be related to both dive depth and activity level (Hays et al. 2000), it is unlikely that a sea turtle would incur such a lack of oxygen that it would develop metabolic acidosis. Furthermore, we also know that green sea turtles (Chelonia mydas) and loggerheads already use their lungs as a major oxygen store (Lutcavage and Lutz 2006). But according to the behaviour we have observed during this study it could still be interesting to investigate sea turtles’ seemingly particular interest for the calcium-rich shells of clams.

The turtles that were used in this study could also have been eating the shell as a means of enrichment rather than by need or hunger. The animals were held at Oceanografic as part of a rehabilitation program. As such, their tanks were simple, with no source of distraction but the food that was given to them daily, with the exception of Wednesdays and the weekends. In addition, one could assume the turtles were eating more regularly than they do into the wild. As such they were probably never terribly hungry anytime we performed a feeding experiment and the results presented here should be considered with caution. The results could have been influenced by the turtles’ health or state of hunger (especially concerning the “shell eating” behaviour). The duration of the approach phase could have also been influenced by the habituation of the turtles to the experiment. However, most of the individuals were tested only a couple of times, so it is unlikely they would have been able to learn the feeding routine. But if they did, then this could have influenced the duration of the approach phase which could then be much different from what could be observed in the wild. The tanks were also quite small, so the turtles would not have to chase crabs for very long before catching them. Indeed, the different sizes and temperatures of the tanks could also be seen as possible confounding variables.
Finally, as detailed in the Section 3.2, the turtles were not fed the Wednesday and weekends and thus could possibly be hungrier on the Monday than on the Thursday due to being without food for a longer period. As a consequence, they were maybe more willing to eat the clams on Mondays, which they would not have been if they were given the clams on Thursdays. It would have been useful to alternate the days on which crabs and clams were given to see if this affected the turtles feeding behaviours.

5.4 Concluding remarks

The diet of sea turtles is quite complex and wide. Some species are carnivorous and eat lots of different kinds of prey, from fishes, to sponges, urchins, molluscs, etc as it is the case for the loggerhead and the olive ridley sea turtle (Lepidochelys olivacea) (Netting and Pope 2006). The leatherback sea turtle almost exclusively feeds on jellyfish while the hawksbill (Eretmochelys imbricata) prefers sponges, which is a rare source of food among marine animals (Meylan 1988). The green sea turtle on the other hand, if carnivorous when juvenile, almost exclusively eats seaweed as an adult (Devaux 2000). Sea turtles’ diets can indeed also vary through their lifetime and development, but also in relation to their environment. Consequently, a loggerhead might not eat the same type of food when it is overwintering in the Mediterranean Sea than when it is foraging on the Californian coasts, or when it is swimming in a benthic or in a pelagic zone. With all these possible sources of differences, one could assume a wide range of feeding and foraging behaviours among sea turtles. With the results of the present study, it seems like different types of prey result in different approach and feeding phase durations in loggerhead sea turtles. The type of prey also seems to influence the energy an animal is going to spend in order to get it, which calls into question the relationship between the energetic cost of obtaining a prey and its energetic value. One could assume that a loggerhead or an olive ridley would easily spend more energy while foraging for crabs or fishes than a green sea turtle eating mostly seaweed which is on the other of lower calorific value than a crab. And once again, monitoring and understanding all those possible differences could potentially help to enhance the success of conservation projects and thus the survivability of the sea turtles of which many species are currently threatened or even critically endangered according to the IUCN Red List.
6 Societal and Ethical consideration

Sea turtles are long term studied species and the importance of learning about those animals is becoming more and more important in order to protect them better against the reduction of the population and their vulnerability to Humans’ threats in general. Learning about feeding habits could represents a good opportunity to better understand their behaviour in the wild. If we could become able to recognize what sort of prey (moving or static, benthic or pelagic) a turtle is feeding on and on what frequency, it would be easier to draw a more precise picture of their habits and the importance of some preys in their diet.

Data logger could also be used to compare data collected on healthy individuals with wounded individuals and see how health status can influence the diet and by then survivability of a turtle. Finally, this could also be interesting to compare the diet at different period of the year or the life of an individual.

Diet has already been studied in turtles but usually from feces and direct observations, usually near the cost. The problem with feces is that for some preys, like jellyfish, it is hard if not impossible to notice their presence since they’re entirely digested by the turtles. And when it comes to the direct observations, they’re usually performed on shallow water, whereas we know sea turtles also eat prey that lives in the pelagic areas, but it is then harder to know at what frequency because they’re then harder to observe in those areas due to the deepness of the water.

7 Acknowledgments

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8 References


Appendix

Table 1: Animal ID (ID), entry and release date, Origin, curved carapace length (CCL), body mass (Mb) and pathology/condition.

<table>
<thead>
<tr>
<th>Animal ID</th>
<th>Entry date</th>
<th>Release date</th>
<th>Origin</th>
<th>CCL (cm)</th>
<th>MB (kg)</th>
<th>Pathology/Condition</th>
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<td>11/10/2017</td>
<td></td>
<td>Vinaroz</td>
<td>57</td>
<td>15.8</td>
<td>Carapace trauma</td>
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<td>T348</td>
<td>21/11/2017</td>
<td>13/06/2018</td>
<td>Vinaroz</td>
<td>4.13</td>
<td></td>
<td>Gas embolism</td>
</tr>
<tr>
<td>T385</td>
<td>16/03/2018</td>
<td>20/07/2018</td>
<td>Valencia</td>
<td>40.7</td>
<td>8.6</td>
<td>Gas embolism</td>
</tr>
<tr>
<td>T396</td>
<td>04/04/2018</td>
<td>05/07/2018</td>
<td>Vinaroz</td>
<td>59</td>
<td>22</td>
<td>No pathology</td>
</tr>
<tr>
<td>T397</td>
<td>05/04/2018</td>
<td>03/06/2018</td>
<td>Perelló</td>
<td>39</td>
<td>5.7</td>
<td>Mild drowning</td>
</tr>
<tr>
<td>T399</td>
<td>06/04/2018</td>
<td>08/06/2018</td>
<td>Cullera</td>
<td>40</td>
<td>7.24</td>
<td>No pathology</td>
</tr>
<tr>
<td>T402</td>
<td>16/04/2018</td>
<td>09/06/2018</td>
<td>Burriana</td>
<td>33</td>
<td>7.3</td>
<td>Gas embolism</td>
</tr>
<tr>
<td>T403</td>
<td>06/05/2018</td>
<td>29/06/2018</td>
<td>El Perelló</td>
<td>38</td>
<td>7.24</td>
<td>No pathology</td>
</tr>
<tr>
<td>T404</td>
<td>07/05/2018</td>
<td>06/07/2018</td>
<td>Almenara</td>
<td>30</td>
<td>3.24</td>
<td>Neck injuries</td>
</tr>
<tr>
<td>T405</td>
<td>01/06/2018</td>
<td>12/07/2018</td>
<td>Peñiscola</td>
<td>64</td>
<td>34.24</td>
<td>Gas embolism</td>
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Table 2: Tanks size and temperature

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<tr>
<th>Tank</th>
<th>Diameter</th>
<th>Temperature</th>
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<tbody>
<tr>
<td>A1</td>
<td>4m</td>
<td>19°C</td>
</tr>
<tr>
<td>A2</td>
<td>3m</td>
<td>19°C</td>
</tr>
<tr>
<td>A3</td>
<td>2m</td>
<td>19°C</td>
</tr>
<tr>
<td>A4</td>
<td>2m</td>
<td>19°C</td>
</tr>
<tr>
<td>B1</td>
<td>2m</td>
<td>24°C</td>
</tr>
<tr>
<td>B2</td>
<td>3m</td>
<td>24°C</td>
</tr>
<tr>
<td>B3</td>
<td>3m</td>
<td>24°C</td>
</tr>
<tr>
<td>B4</td>
<td>5m</td>
<td>24°C</td>
</tr>
</tbody>
</table>