A Comparative Behavioral Analysis of Time Budgets of Sea Turtles at The Florida Aquarium through the Application of an Ethogram

by

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Dedication

I dedicate this thesis to my parents, Chris and Krista, for whom I am eternally grateful. Without you, none of this would be possible. Everything I have achieved and ever will achieve is because of you.

I would also like to thank the other top members of my fan club: Jack (my favorite human in the world), Grandma, Aunt Kerry, Donna, Uncle Kyle, Aunt Nancy, Uncle Mike, Andie, Pam, Tiffany, and Emily. A special thank you is reserved for my late Grandma Lowry, who supported my education before I could even speak. You have all contributed to this thesis in ways I could never express.

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Disclaimer

All animals and all data collected, occurred under a Florida Fish and Wildlife Conservation Commission Marine Turtle Permit (MTP #42018/#42019)

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Abstract

Sea turtles are a crucial component of many coastline habitats due to their roles as ecosystem engineers and their ability to raise awareness for conservation efforts. Despite the extensive amount of research conducted on nesting behaviors of wild sea turtles, there are few behavioral studies of turtles in managed care. Sea turtles were observed at The Florida Aquarium from February 2018 to May 2019 to examine possible variations among behavior for five Loggerhead (*Caretta caretta)*, Green (*Chelonia mydas*), and Kemp's Ridley turtles (*Lepidochelys kempii*). The first part of this study includes a baseline time budget for the five turtles using the baseline ethogram developed for this research. The second half of this study addresses five hypotheses that compare turtle behavior based on time of day, time of year, species and enclosure size. A Mann-Whitney U test was used to determine the significance of the results. Results show that there is no significant difference in sea turtle behavior based on these factors. Through the knowledge gained in this study, facilities caring for sea turtles will be able to determine health condition and animal welfare with the use of behavioral analyses.

1. Introduction

1.1 Sea turtle conservation

Rehabilitation of as many injured or ill sea turtles as possible can contribute to the prosperities of each species due to the low survival rate from egg to adulthood and potentially high reproductive output of each individual (Mestre et al., 2014). Zoo and aquarium facilities in the United States have rehabilitation programs for sea turtles. They also showcase sea turtles in exhibits due to their popularity as a flagship species. According to the International Union for Conservation of Nature (IUCN) Red List (2017), Loggerhead (*Caretta caretta*), Olive Ridley (*Lepidochelys olivacea*), and Leatherback (*Dermochelys coriacea*) turtles are classified as vulnerable, Green sea turtles (*Chelonia mydas*) are endangered, Kemp's Ridley (*Lepidochelys kempii*), Hawksbills (*Eretmochelys imbricata*) are critically endangered, and Flatbacks (*Natator depressus*) are data deficient. The IUCN requires extensive data to classify each species, and data regarding subpopulations that may be more threatened than others can be lacking (Robbirt, Roberts, & Hawkins, 2006). All seven species have been subjected to hundreds of years of harvesting (both intentional and unintentional), pollution, and habitat destruction (Mestre et al., 2014).

Green sea turtles have historically been a food source for European colonists and African slaves in the Americas (McClenachan, Jackson, & Newman, 2006) as well as other coastal communities such as Cuba (Bretos et al., 2017). A study by McCleanchan, Jackson, and Newman (2006) estimated that current populations of Green turtles are 0.27-0.33% of their historic populations due to harvesting of entire nesting populations and the ease of capture during nesting by adult females. Eggs of the turtles have also been exploited, either by capturing mothers still holding their eggs or directly for consumption (Olijdam, 2001). Many countries banned harvesting of sea turtles and their eggs in the 1990s, but some allowed indigenous local fishing communities to continue for several more years. Two communities in Cuba were permitted to continue hunting after the national ban in 1995, but were also banned in 2007 after finding they were still catching 18 tons of Loggerhead, Green, and Hawksbill turtles each year (Bretos et al., 2017).

Warm coastal habitats where sea turtles need to nest also attract people, which leads to habitat destruction for human development. Anthropogenic development creates light pollution, obstructions such as sea walls and parking lots, and a lack of nesting vegetation that can completely deter nesting females (Harewood & Horrocks, 2008). Artificial light sources can also lead to disorientation in hatchlings causing increased predation risk by terrestrial species and death from exhaustion (Harewood & Horrocks, 2008). In combination with sea level rise, erosion, and storm over wash, this leads to an extreme decrease in nesting habitat range (Pike, 2013).

Common reasons for sea turtles to enter rehabilitation programs are boat strikes, injury from bycatch, entanglement, viruses (Jones et al., 2016), and cold-stunning (Innis et al., 2007). Lewison et al. (2014) defined bycatch as "incidental capture of nontarget species" and stated that among seabirds, marine mammal, and sea turtles, the turtles face the highest rate of bycatch, as 85,000 turtles were trapped in fishing gear from 1990 to 2008. Fisheries bycatch is considered a primary driver in sea turtle population declines and is a threat to all seven species (Wallace et al., 2010). Wallace et al. (2010) found that a maximum of 19.3 turtles per 1,000 hooks in longlines, 2.2 turtles per set in gillnets, and 7.2 turtles per trawl were entangled and caught as bycatch.

Convergence zones are defined as areas where strong ocean currents meet that are often biologically diverse and mark current boundaries (Yoder et al., 1994). These convergences, such as rips, drift lines, and oceanic fronts are how turtles make their long migrations for feeding purposes (Carr, 1987). Carr (1987) states that this is a problem for these turtles because marine debris such as commercial fishing gear often accumulates in these fronts. He explains that juveniles frequently confuse this debris for Sargassum refugia for feeding and protection, which can lead to entanglement and consumption of plastic that may present itself as a common food item like jellyfish (Carr 1987). Entanglement can lead to prevention of diving and surfacing, amputation of limbs, and increased predation from open wounds (Mascarenhas & Zeppilini, 2004).

A common virus in most species of sea turtles is fibropapilloma disease, which can cause tumors, both externally and internally (Chaloupka & Balazs, 2005). Fibropapilloma is also known to slow somatic growth in turtles and the cause of many strandings can be attributed to the disease (Chaloupka & Balazs, 2005). Another reason for sea turtle stranding is cold-stunning, which occurs when turtles are in rapidly decreasing water temperatures (Innis et al., 2007). Cold-stunned turtles often become lethargic, remain on the surface, and often die from stranding (Innis et al., 2007).

As rehabilitation of sea turtles continues at facilities around the world, they have inadvertently become a flagship species. Leader-Williams and Dublin (2000) define flagship species as one that incites sympathy in the public that leads to motivation towards conserving the species, the species usually being an example of 'charismatic megafauna.' Frazier (2005) states all seven species of sea turtles are considered flagship species and the world spends $20 million yearly for their conservation, he categorizes them with other notable conservation species such as whales, rhinos, and the Giant Panda. The title of flagship species is often mistaken for roles such as keystone species, indicator species, or umbrella species that often have a specific ecological role, but is only indicative of its social role within the public (Frazier, 2005). This social role can translate into a benefit for the ecosystem surrounding sea turtles through invoking awareness for ecological conservation. Frazier (2005) explains that tourism involving observations of sea turtles can lead to fundraising for the conversation of the species (thereby leading to conservation of their habitats), increasing education and awareness of the public on threats to biodiversity, and generating more interest in conservation volunteer work.

According to the Association of Zoos & Aquariums (AZA), 89 AZA-accredited zoos and aquaria contributed over $1.2 million to sea turtle field conservation through state agencies, health assessment, tagging, nesting, rehabilitation, and rescue programs in 2013. The Florida Aquarium website states since their opening in 1995 their team of veterinarians, volunteers, and biologists have successfully rescued and released more than 210 sea turtles into the wild (The Florida Aquarium, n.d.). They are partnered with the Florida Fish and Wildlife Conservation Commission, University of Florida, University of South Florida, U.S. Fish and Wildlife Service/National Refuge System, and the Florida State Park Service for sea turtle rehabilitation and rescue. The Florida Aquarium is also a member of the Sea Turtle Stranding and Salvage Network for the Gulf of Mexico and

Southeast Coast. For this study, the rehabilitation turtles were kept on site at The Florida Aquarium until the Sea Turtle Rehabilitation Center in Apollo Beach, Florida opened on January 23, 2019, which includes a new deep diving tank as well as smaller systems for recovering animals (The Florida Aquarium, n.d.).

1.2 Sea turtle ecology

Cheloniodiea is a superfamily under the order of Testudines that encompasses the seven species of sea turtles. Six of the seven species, all except *D. coriacea* (Dermochelyiidae), are in the family Cheloniidae. These sea turtle species are known for their charismatic nature, lengthy migrations, their vulnerability due to the many anthropogenic impacts that affect our oceans today, and are popular subjects of ecotourism (Frazier, 2005). According to the IUCN Red List, there are approximately 22,341 mature *Lepidochelys kempii* as of 2019 and 36,000-67,000 nesting *Caretta caretta* females as of 2015. The IUCN does not have a current estimate of *Chelonia mydas*.

The Florida Aquarium currently houses two *Chelonia mydas*, one *Caretta caretta*, and two *Lepidochelys kempii* at their facility for rehabilitation or permanent residency. *C. mydas* are highly migratory, with some travelling from 1200 to 2680 kilometers between breeding and foraging grounds (Read et al., 2014). They are an herbivorous species that have distinct populations in tropical and subtropical areas of the Atlantic, Pacific, and Indian oceans (Yang, Wang, & Chen, 2015). *C. caretta* are the most migratory sea turtle species, having home ranges of up to 4000 square kilometers with populations in the same oceans as Green turtles, but in more temperate and subtropical waters (Hawkes et al., 2011). *L. kempii* are the most endangered and have the smallest range of any sea turtles, living only in the Gulf of Mexico and in the warm temperate waters of the northwestern Atlantic (Shanker et al., 2004). There were 90.1% fewer nests of *L. kempii* in 2014 than those recorded in 1947 (Bevan et al., 2014).

Sea turtles were considered ecosystem engineers until their extreme population decline due to overharvesting by humans (Bjorndal & Jackson, 2002). Jones, Lawton, and Shachak (1997) defined ecosystem engineers as “organisms that directly or indirectly control the availability of resources to other organisms by causing physical state changes in biotic or abiotic materials” (p. 1). Sea turtles made contributions to their ecosystems due to their massive population sizes prior to overharvesting and their roles as nutrient transporters, competitors, prey, predators, carriers of epibionts and parasites, and landscape modifiers (Bjorndal & Jackson, 2002).

Bjorndal and Jackson (2002) stated *C. caretta* are relatively well-studied as compared to other species of turtles in terms of their ecological roles. They describe *C. caretta* as being an important predator to shellfish as well as important prey to larger animals, especially in their juvenile stages. Thirty-seven taxa of algae and almost 100 epibionts have been found on nesting *C. caretta* shells (Bjorndal & Jackson, 2002). *C. caretta* also provide nutrient transport by consuming nutrients in foraging grounds where they are rich and depositing the nutrients in the form of their egg clutches on nutrient-poor beaches (Bjorndal & Jackson, 2002). *L. kempii*, one of the most endangered species of sea turtle, are considered opportunistic feeders and their diets are similar to those of *C. caretta* (Schmid & Tucker, 2018). Schmid & Tucker (2018) state that these turtles’ diets vary in different ecosystems based on whatever the most abundant prey source is, but there is no observed difference between the diets of mature and juvenile turtles.

C. mydas in the Caribbean feed mostly on turtlegrass (*Thalassia testudinum*) and they previously trimmed 86% of the total area of seagrass beds hundreds of years ago prior to overexploitation (McClenachan, Jackson, & Newman, 2006). McClenachan, Jackson, and Newman (2006) explain that the harvesting of *C. mydas* eventually led to the seagrass beds being transformed into a detritus-based ecosystem that is characterized by seagrass wasting disease and unmetabolized cellulose from fish waste that cannot be used for productivity in the system. Seagrass beds that are left ungrazed can have higher amounts of hypoxia, infection from pathogens, and higher sulfide toxicity than beds grazed by *C. mydas* (Bjorndal & Jackson, 2002).

1.3 Animal welfare

Hewson (2003) states that there are three common definitions of animal welfare. She begins with the most antiquated definition, previously used by farmers and veterinarians: if an animal is reproducing and in good health, the animal is doing well. This definition is problematic as animals can be mentally unwell despite being in good health, which led scientists and others working with animals to begin to include feelings into their consideration for animal welfare (Hewson, 2003). The second perspective on this subject uses behavior as a measurement of feelings, wherein if an animal is able to satisfy their behavioral needs, they are mentally well (Hewson, 2003). Hewson concludes her review by stating that the third and most widely-accepted definition of animal welfare includes both the animal's mind and body, and the animal must be able to carry out behaviors that they would in nature (2003). For example, an animal welfare assessment of sea turtles could include their natural behaviors such as foraging, swimming, and resting.

Changes in animal behavior are often the first sign of health problems such as injuries, diseases, or environmental stressors due to unsatisfactory enclosures (Warwick et al., 2013). Despite the common belief that mammals and birds are more behaviorally complex than reptiles, reptile behavior can match, or even surpass, behavioral diversity of these species (Warwick et al., 2013). Warwick et al. (2013) suggest that there is a severe gap in behavioral baseline data for animals in managed care. Not only is there a lack of information of these animals' behavior in the wild, but also for their behavior in managed care while they are healthy and environmentally satisfied. Behavioral studies can also be more effective at measuring stress than physiological indicators such as cortisol, which can indicate signs of agitation but does not always reflect signs of anxiety or depression in animals (Warwick et al., 2013). Blood tests for cortisol levels may also not be able to be collected often from animals in managed care due to the stress resulting from retrieving the animal from its enclosure.

1.4 Animal behavior

The origin of animal behavior scientific studies can be attributed to European scientists from the 17^{th} to 19^{th} centuries, such as Charles Darwin and John Ray, but was further expanded to include more aspects of ecology and biology by scientists in the 1930s including N. Tinbergen and K. Lorenz (Seely & Sherman, 2017). The scientific and objective study of animal behavior is referred to as ethology (Thorpe, 1979). In 1963, Niko Tinbergen developed four categories to explain of both animal and human behavior: function, phylogeny, mechanism, and ontogeny (Tinbergen, 1963). These categories help behavioral scientists determine how and why behaviors occur in both the present and evolutionary senses. Konrad Lorenz did not agree with behavioral studies that occurred in a laboratory setting, and thus began studying bird behavior in the wild. He determined that bird behaviors are mostly innate, but can be triggered by their environment, which led him to his pioneer discovery of imprinting in juvenile birds (Lorenz, 1937). Together, Tinbergen and Lorenz won the Nobel Prize in Physiology or Medicine in 1973 (Burkhardt, 2005).

Ethological studies are scarce in the conservation biology community, but a review paper by Sutherland, "The Importance of Behavioral Studies in Conservation Biology," (1998) states the importance of this field in conservation. Behavioral studies are critical in some aspects of conservation biology due to the importance of behavioral skills in the successful release of translocated or captive-bred animals, difficulty of captive breeding of endangered species'; behavioral consequences of environmental change; dispersal in fragmented population; predation reduction for endangered species; and, mating systems after inbreeding depression.

1.4.1 Ethogram and sampling

Often times, animal behavior studies use an ethogram, a list of behavioral categories that usually contain a description and code for each behavior for ease of data entry (Ottoni, 2000). Ethograms are a useful tool for both creating baseline data for animal behavior and comparing behavior of individuals of the same species (Liu et al., 2009). Ethograms can be used with a wide variety of sampling techniques such as focal-animal, instantaneous, and scan sampling. Focal-animal sampling involves observing one animal for a length of time and recording every behavior, as well as the duration of that behavior, throughout the observation period (Altmann, 1974). Instantaneous sampling is a technique used in behavioral studies where the behavior of an individual is recorded at preselected time intervals, which can be useful for determining relative frequencies of behaviors also known as a time budget (Engel, 1996). Scan sampling is a form of instantaneous sampling that is used on groups and can determine behavioral states of a group and behavioral synchrony (Altmann, 1974). Animal behavior observers can use the information in an ethogram to note the behavior taking place at each interval in order to create a time budget for each individual, which then can be compared to other individuals. This allows for the qualitative data of behavior to be translated into more quantitative and usable data.

1.4.2 Bias against reptiles in ethology

Most behavioral studies involving captive animals target those that live on land (mostly vertebrates and larger animals), or marine mammals such as dolphins (Therrien et al., 2007). In 1990, 43.7% of research projects in zoos were conducted on primates, especially focusing on the great apes (Melfi, 2005). Warwick (1990) states that there are two reasons for the focus of behavioral studies to be on mammal and avian species and not on reptilians. The first explanation is that abnormal behavior in reptiles does not manifest in ways that are easily recognizable to humans, such as a chimpanzee rocking back and forth like an upset child (Warwick, 1990). Warwick's (1990) second reason is the common perception that reptiles' ability to assimilate to living in managed care is higher than greater vertebrates. Burghardt (1977) argues that reptile behavior can often match or even exceed the behavioral diversity of certain mammals and avians.

1.4.3 Reptile behavior

Warwick (1990) states that reptiles, unlike mammals and avians, are born with innate behavior (which is the knowledge of how to survive) and do not learn from their parents. Therefore, it can be disputed that due to their increased ability to learn behaviors in these mammals and birds, they may be more adaptable to captive environments than reptiles (Johansson, 2017). Along with the issue of lack of behavioral studies, reptile ethological studies also often take place in a controlled, lab environment opposed to in the wild or in an enclosure in an aquarium or zoo (Case et al., 2005).

Several studies have been carried out on freshwater turtles using ethograms. Liu et al. (2009) observed 75 behaviors of 15 Four-Eyed turtles (*Sacalia quadriocellata*) and were the first to study this species. Jackson and Davis (1972) monitored courtship of captive Red-Eared turtles (*Chrysemys scripta elegans*) which takes place during swimming. The courtship behaviors were monitored using video and were assessed using a detailed ethogram that outlined all steps in the process of mating. Burghardt, Ward, and Rosscoe (1996) were the first to detect playing behaviors in reptiles while observing the Nile Soft-Shelled turtle (*Trbnyx triunguis*). The captive male turtle was found to display less self-destructive behaviors after being given enrichment devices, which was categorized as play.

Case et al. (2005) conducted a study comparing the effect of enriched versus barren enclosures on behavioral and physiological measures in the Eastern Box turtle (*Terrapene carolina carolina*). It was found that the turtles would choose an enriched environment over a barren environment when given the option. Case et al. (2005) also found that the turtles in enriched environments had a lower heterophil to lymphocyte ratio (H/L), which is a physiological response that can be used to measure stress with higher H/L ratios reflecting more stress in an individual. Finally, Case et al. (2005) revealed that turtles in barren enclosures spent significantly more time in escape behaviors, such has hitting enclosure walls with their heads repeatedly, pacing, wall climbing, and digging against enclosure walls. These studies on aquatic turtles were imperative to the progression of reptiles, especially Testudines, being studied in a quantitative manner to measure behavior and can be used to give better care to these species while in managed care.

1.4.4 Sea turtle behavior

Most sea turtle behavioral studies occur in the wild while turtles are nesting or in near-shore habitats. Heithaus et al. (2002) used animal-borne video cameras on *C. mydas* and *C. caretta* sea turtles in Western Australia to observe diving, surfacing, feeding, and self-grooming behaviors. They discovered that *C. mydas* turtles, previously thought to be entirely herbivorous, were feeding on jellyfish and ctenophores and also groomed more on rocks when cleaner fish species were not present (Heithause et al., 2002). Most diving behavior of wild turtles is documented using time-depth recorders, but these lack the ability to record specific activities taking place while turtles are submerged. Houghton, Woolmer, and Hays (2000) took advantage of very shallow water near Kefalonia, an island off the coast of Greece, to observe behaviors of *C. caretta.* This study revealed that these turtles fed mostly on discarded fish from fishermen, seagrass, and bivalves and that deeper dives could occur at a longer duration than those of shallower foraging dives.

One behavioral study by Parrish (1958) examined the behavior of *L. kempii*, *C. mydas*, *E. imbricata*, and *C. caretta* turtles in managed care at Marineland in Florida using a qualitative format. Parrish (1958) generalized what he found into the following categories: temperament, feeding behavior, respiration, scratching, territoriality, resting, sleeping, and locomotion. Parrish (1958) stated the turtles exhibited personalities but there were not any distinct behavioral differences between the turtles. Another study regarding sea turtles in managed care comes from Therrien et al. (2007) who gathered data from the Mote Marine Laboratory and Aquarium in Sarasota, Florida using an ethogram. Turtle behaviors were examined after enrichment devices were placed in turtle enclosures. The ethogram consisted of the following categories: resting, pattern swimming, random swimming, aggression, focused behavior, orientation toward the enrichment device, hiding, and noncategorized. The researchers found that enrichment devices can be used to increase activity and reduce aggression in captive sea turtles, which is beneficial for both the turtle and the aquarium visitors (Therrien et al., 2007). This study was replicated by Lloyd et al. (2012) with four *C. mydas* turtles housed in the School of Veterinary and Biomedical Sciences at James Cook University. Similarly to Therrien et al. (2007), this research determined that enrichment devices reduced pattern swimming and resting behaviors.

1.5 Objectives

Due to the lack of long-term sea turtle behavioral examination in managed care, the goals of this study are to: (1) create a baseline ethogram and time budget for each sea turtle and (2) compare behavior between turtles in managed care at The Florida Aquarium in Tampa, Florida based on several factors including: species type, time of year, time of day, and size of enclosure, while using an ethogram as the data visualization tool. Aquaria could consider the information found in this study to better adjust to the individual needs of sea turtles for a higher quality and perhaps a faster pace of rehabilitation and possible release.

1.6 Hypotheses

The hypotheses for the comparative behavioral analysis are as follows:

- Null: There is no difference in amount of time spent in active behaviors in turtles between morning and evening.
- Alternative: Turtles will spend more time active in the evening than in the morning.
- Null: There is no difference in amount of time spent respiring between morning and evening.
- Alternative: Turtles will spend more time respiring in the evening than in the morning.
- Null: There is no difference in amount of time spent swimming between winter versus spring.
- Alternative: Turtles will spend more time swimming in winter versus spring.
- Null: There is no difference in amount of time spent swimming between *C. mydas* and *L. kempii*.
- Alternative: *C. mydas* will spend more time swimming than *L. kempii*.
- Null: There is no difference in amount of inactive time between turtles in large enclosures and turtles in small enclosures.
- Alternative: Turtles will spend significantly more inactive time in large enclosures than turtles in smaller enclosures.

2. Methods

Five sea turtles at The Florida Aquarium in Tampa, Florida were included in this study named: “Flip,” “Shelldon,” “Banner,” “Pistachio,” and “Ludwig.” “Flip,” “Shelldon,” and “Ludwig” are resident turtles and “Pistachio” and “Banner” are rehabilitation turtles. I define resident turtles as those who are deemed non-releasable, live in larger enclosures, and/or have been in managed care for over ten years. Rehabilitation turtles are those who are often in smaller enclosures and are managed in such a way as to make them suitable candidates for eventual release. Additional information regarding each turtle is provided in Table 1. Artificial lighting above the turtle enclosures mimicked natural lighting and each turtle was on a regular feeding regimen.

Observations were filmed with a PowerLead 720 P 16 MP camcorder. For resident turtles, filming took place in public areas of the aquarium where the enclosure could be viewed from the side. Rehabilitation turtles were filmed in their smaller enclosures from above. Cleaning, feeding, and entertainment schedules were considered to avoid any disturbances during the observation period. Instantaneous sampling was used to record each behavior occurring every 30 seconds.

Observations for resident and rehabilitation turtles were carried out in two separate parts using distinct methods. The goal of the first part of this study was to create a baseline ethogram and a time budget for each turtle. Videos from the second part of the study were used to provide standardized data with which to compare behaviors among turtles.

2.1 Baseline ethogram

Observations for the baseline ethogram took place from March 2, 2018 to October 28, 2018. Videos were recorded of each turtle in both the morning and evening, then manually analyzed after each session. Morning videos were recorded between seven and nine AM and evening videos were recorded from five to seven PM, each video was thirty minutes long. Instantaneous sampling was chosen for this study and the turtles' behavior was recorded every 30 seconds. Instantaneous sampling was chosen due to the ease of building a time budget with the data. This data was entered into an Excel spreadsheet that consisted of the turtle's name, date of observation, time of video, and behavioral code. This data was used to create an ethogram that encompasses all behaviors that were exhibited by at least one turtle (Table 2). The ethogram is divided into event, code, and description. The event refers to the behavior taking place for the turtle each thirty seconds. Codes are given to each event in order to have a more concise data sheet with more ease of recording in real time. The event's description can be used to distinguish each behavior and to assist in future replications of this study.

To create time budgets for each turtle, contingency tables were created in Excel for each of the turtles' behaviors. These tables were then used to create charts that reflect the percent of total time spent in each behavior for all turtle species observed. It is important to note that not all turtles can carry out every behavior. Turtles in the 500-1,500-gallon enclosure could not rub on rocks, dive, surface, or aggress towards any other species due to being kept apart from other individuals and a lack of rocks in the enclosure. “Flip” could not aggress towards another turtle as she was the only one in her system.

2.2 Comparative behavioral analysis

The second part of this study was conducted for ten weeks from January 18, 2019 to May 11, 2019. After the ethogram and time budgets were collected during the first half of the study, standardized data on each turtle was recorded to determine differences in behavior between groups of turtles. “Flip,” “Shelldon,” and “Ludwig” were filmed each week on Mondays and Wednesdays at the same time of the morning and evening for thirty minutes. “Pistachio” and “Banner” were filmed on Tuesdays and Thursdays for thirty minutes at the same time. Every turtle was filmed for a total of ten hours, equating to 1200 data points, with the exception of “Ludwig,” who was filmed for only five hours as he was transferred to another enclosure. Similar to the baseline ethogram protocol, each video was analyzed using instantaneous sampling and data was entered into an Excel spreadsheet. The standardization of the length of each video, filming time, and filming day allowed for more precise data for analysis.

2.2.1 Statistical analysis

Contingency tables for each hypothesis were constructed in Excel from the data recorded. I performed a two-tailed Mann-Whitney U test to examine the behavioral differences between the five turtles based on factors listed in the hypotheses stated in section 1.6. A p-value of <0.05 was considered significant. All tests were conducted using the IBM SPSS Statistics 25 application.

3. Results

A summary of all five turtles' behaviors categorized by species is provided in Figure 1. Each behavior displayed from data collection in both parts of the study was included in the ethogram (Table 2). New behaviors observed in the second part of this study were also added to the ethogram. Behaviors listed may have occurred in only one turtle in this study. The behaviors observed are as follows: aggression toward shark, aggression toward ray, awake, between breaths, bite at enclosure, chasing sea turtle, crawl, dive, edge swim, hover, mount rock, out of sight, respire, rub on rock (left or right side), scratch face, sleep, surface swim, and swimming under running water.

3.1 Baseline ethogram

"Flip" (*Chelonia mydas*), a 55-65 year old turtle with injuries to her flippers and has buoyancy issues, was held in a 300,000-gallon enclosure that is 26 ft. deep. Other species such as Nurse sharks, Sand Tiger sharks, and a variety of reef fish occupy the same enclosure. Figure 2 documents "Flip's" time budget. In this part of the study, she was the only turtle to display aggression towards a ray and rubbing against rocks on either side of her body. "Flip" spent 73.7% of her time sleeping and she was awake 9.5% of the total time observed. When she rubbed on rocks, she used the right side of her body against the rocks 3.3% more than her left side.

"Shelldon" (*Caretta caretta*) is a two-to-four-year old turtle that lived in small enclosures ranging from 500- to 1500-gallon enclosures in the beginning of the study to a large, 90,000-gallon and 10 ft. deep enclosure for the second half of the observed time period. While in the smaller enclosures, he was kept by himself but cohabitated in the larger enclosure with “Ludwig,” bonnet head sharks, and reef fish. “Shelldon” has full use of all flippers, but suffers from an esophagus injury from entanglement. His time budget can be found in Figure 3. “Shelldon” was one of the most active turtles, his first and third most prevalent behaviors were hover (44.1%) and crawl (15.1%). He spent the least amount of time sleeping of all five turtles at 0.4% and the most time respiring at 4.8% during the study period.

“Ludwig” (*Lepidochelys kempii*) is one of the two oldest turtles in this study at approximately 55-65 years and has no apparent health concerns. He was kept in the same enclosure as “Shelldon” and his behavioral observations are provided in Figure 4. “Ludwig” was the only turtle to display two of the aggression behaviors, aggression towards shark and chasing sea turtle (“Shelldon”). He also spent the most time sleeping of all turtles at 80.6%. Between “Ludwig’s” time spent awake and sleeping, he had the highest percentage of inactive behaviors. “Ludwig” displayed no grooming behavior throughout the entirety of the study.

“Pistachio’s” (*Lepidochelys kempii*) time budget is provided in Figure 5. Her enclosures were small (500- to 1500-gallons) and she was always the only individual in the enclosure. Pistachio’s approximate age is ten to twelve years. She is the only sea turtle who may be releasable as her boat strike injuries are healing, but she may have vision issues in one eye and is being evaluated with food trials. “Pistachio” spent most of her time either crawling (38.4%) or hovering (23.8%). There were no behaviors unique to “Pistachio” and she spent no time in grooming behaviors, similar to “Ludwig.”

“Banner” (*Chelonia mydas*) was also kept by himself in the smaller enclosures and is estimated to be between four to six years old. He is also another victim of a boat strike and his wound has healed, but he was left with buoyancy issues and a permanent spinal injury. “Banner’s” time budget is provided in Figure 6. Not only was “edge swim” his most common behavior (46.5%), but this behavior was only found in budgets of the other turtles at 2.3% or less. He also spent the most time of any turtle swimming under running water in his enclosure (11%). “Banner” had the least inactive behavioral budget at only 10.5% during the study.

3.2 Comparative behavioral analysis

The results addressing the five hypotheses for the second part of this study are as follows. The number of times active was recorded in both the morning and the evening, which included every behavior other than awake and asleep. Differences in the activities were compared between morning and evening (Figure 7). A Mann-Whitney U test determined a p-value of 0.465. While there was no significance between activity levels during the morning (Mann–Whitney U = 9.00, $n_1 = n_2 = 5$, P = 0.465 two-tailed), “Shelldon” had the largest difference between time of day with a 20.6% decrease in activity from morning to evening. “Banner” not only spent the most time active of all turtles, but also had the smallest difference between morning (76.9%) and evening (74.3%). “Ludwig” was the least active in the morning at 20%. The average time spent active for all turtles was 51.4% in the morning and 42.3% in the evening.

Figure 8 shows the amount of time the turtles spent respiring in the morning and evening. There was no significant difference found between respiring and time of day (Mann–Whitney U = 9.50 $n_1 = n_2 = 5$, P = 0.530 two-tailed). “Banner” spent the most time respiring out of all turtles in both the morning (5.12%) and evening (6%). “Ludwig” spent the least amount of time breathing in the beginning of the day (2%), while “Flip” spent the least time at the end of the day at 1.17%. There was very little difference in average time spent respiring across all turtles with 3.76% in the morning and 3.20% in the evening.

For the second part of the study, the following behaviors were consolidated into one swimming category: hover, dive, surface swim, and between breaths. When comparing winter to spring in terms of the number of times recorded spent swimming for four turtles, there was found to be no significant difference between the two times of year (Mann–Whitney U = 6.00, $n_1 = n_2 = 4$, P = 0.564 two-tailed). “Ludwig” was not included in this group as all of his filming occurred during the months of January and February. Figure 9 displays the recorded number of times for each turtle engaged in a swimming behavior, with all four turtles swimming more in the beginning of the year except for “Flip.” “Banner” spent the most time swimming at both times of year than any other turtle at 45.6% in winter and 42.4% in spring. “Flip” spent the least time swimming at the beginning of the year (4.83%) and “Pistachio” spent the least time swimming in the spring (11.8%). “Pistachio” also had the largest difference between times of year, with her swimming 37.7% of the time in winter.

When comparing the two Green turtles to the two Kemp’s Ridley turtles, there is no significant difference between the amount of time spent swimming (Mann–Whitney U = 1.00, $n_1 = n_2 = 2$, P = 0.439 two-tailed). “Banner” spent the largest percentage of his time swimming (43.67%) and “Ludwig” spent the least (9.34%), illustrated in Figure 10. The Green turtles had the first and third largest time budget for swimming and the

Kemp's had the second and fourth. "Flip" and "Banner" spent an average of 27.92% of the time swimming, while "Ludwig" and "Pistachio" averaged 15.76%.

Sea turtles were categorized based on enclosure size to determine if that factor affected the recorded number of times the turtles were inactive, which includes both of the rest behaviors: sleep and awake. "Flip," "Shelldon," and "Ludwig" are held in enclosures greater than 90,000-gallons (large) and "Banner" and "Pistachio" spent their time in enclosures from 500- to 1500-gallons (small). There was no significant difference (Mann–Whitney U = 3.00, $n_1 = 3$, $n_2 = 2$, P = 0.083 two-tailed) in time spent inactive distinguished by the size of enclosure. All three turtles in large enclosures spent a larger percent of time inactive than the two turtles in small enclosures (Figure 11). "Ludwig" spent the most time inactive of any turtle at 77.8% and "Banner" spent the least at 24.3%. Turtles in large enclosures spent an average of 67.23% of time inactive and those in small enclosures spent an average of 31.85% of time inactive.

4. Discussion

This study is the first to establish a detailed ethogram for sea turtles in managed care and to compare these behaviors based on time of day, time of year, enclosure size, and species. As a result, this created an important baseline of behaviors for these sea turtle species in captivity. Due to the importance of sea turtles in their ecosystems and their vulnerability status, having as much information as possible can facilitate their protection. The results of this study can be used not only by The Florida Aquarium, but by all other aquaria with sea turtles. Utilization will help to identify behavioral problems that could be a symptom of health conditions or insufficient environmental enrichment. Assessment of animal behavior is essential for maintaining their welfare and health (Warwick et al., 2013).

4.1 Baseline ethogram

The ethogram created for this study can be compared to the study by Therrien et al. (2007) on sea turtle behavior with enrichment devices in managed care. This study did not include hiding or focused behavior, as enrichment was not being included in the enclosures, but behaviors such as grooming, edge swimming, crawling, and interspecific aggression were identified in the turtles at The Florida Aquarium. Each sea turtle had a relatively unique time budget when compared to the others, which can be explained by consideration of factors such as enclosure size, health condition, species, age, and time spent in managed care.

As the sea turtle with the largest and most enriched enclosure, and a wide array of species contained in the same area, “Flip” (*Chelonia mydas*) spent the most time grooming and a majority of her time sleeping. According to Morgan and Tromborg (2007), some major sources of stress in captivity are restricted movement and absence of retreat space. “Flip’s” ability to hide among the artificial reefs and swim throughout her 300,000-gallon enclosure may allow her to exist with a lower level of stress. This may be reflected in her behavior- she feels safe enough to rest and spend time grooming more than the other turtles in this study who have smaller enclosures and environments with less enrichment.

Another interesting note about “Flip’s” grooming behavior, though it is not significant, is that she spent 3.3% more time rubbing on rocks on her right side than her left side. Along with buoyancy control issues and limited use of two of her flippers, the injury she suffered left her with a dent on the right edge of her carapace. Her tendency to scratch on her right side may be due to the injury and could signify that she still feels a sensation on that side of her carapace. Excessive grooming behavior has been found in rats following pain caused by spinal cord injuries (Brewer & Yezierski, 1998).

“Shelldon” (*Caretta caretta*) was in the 500- to 1500-gallon enclosures for the first part of this study, which were circular and four feet deep. These enclosures did not include any environmental enrichment and consisted of blue walls with one small glass window on the side. “Shelldon’s” most common behaviors were hovering (44.1%), awake (28.5%), and crawling (15.1%). Of the turtles in the smaller enclosures, he spent the most time hovering and the least time sleeping. Although hyperactivity can be a signifier of stress in managed care (Warwick, 1990), “Shelldon” also spent most of his time swimming during the second half of this study when he was moved into a larger enclosure with environmental enrichment.

“Ludwig” (*Lepidochelys kempii*) was the most inactive turtle (87.7%) out of all five and spent the rest of his time mostly crawling (4.1%) and hovering (2.9%) in his 90,000-gallon enclosure. Although the line can be hard to draw between normal sedentary behavior of sea turtles and hypoactivity, hypoactivity in reptiles may be associated with symptoms of anorexia (Warwick, 1990). As “Ludwig’s” feeding was not observed for this study, his feeding habits cannot be tied to his inactivity.

Aggression towards “Shelldon” as well as a shark were also in “Ludwig’s” behavioral repertoire, two behaviors not found in the other turtles. Although “Ludwig” and “Shelldon” are the only turtles living in one enclosure together, “Shelldon” did not aggress towards “Ludwig.” As a sea turtle living in managed care for at least 45 years, it is difficult to determine the type and quality of enclosures in which “Ludwig” has lived previously. Previous stressors may have an effect on his current behaviors at The Florida Aquarium. The only two turtles housed together at Mote Marine Laboratory and Aquarium during Therrien’s 2007 study also displayed aggression towards one another, but only when no enrichment was provided in the enclosure. The United States Department of the Interior (2013) also states that *C. caretta* and *L. kempii* are more prone to aggression towards enclosure mates than other species.

“Pistachio’s” (*Lepidochelys kempii*) time budget was more evenly distributed throughout the behaviors; her three most displayed behaviors including crawling (38.4%), awake (24.0%), and hovering (23.8%). Although she did not spend much of her time in resting behaviors when compared to “Flip” and “Ludwig,” she spent the most time sleeping of the three turtles housed in smaller enclosures. The diversity of her time budget and ability to spend time resting in a small enclosure may be a reflection of her potential ability to be released. For sea turtles to be released from managed care, the attending veterinarian must carry out a physical exam and review the turtles' complete history (The United States Department of the Interior, 2013). The turtle must be able to carry out behaviors needed in the wild, most importantly feeding, and have a completely clean bill of health. Out of all five turtles, "Pistachio's" behavior should be monitored closely to determine if release into the wild is the best decision for her wellbeing.

The most abnormal behavior, when compared to the other sea turtles, was displayed by "Banner" (*Chelonia mydas*). Despite having the same enclosure size as "Pistachio," and having a buoyancy issue similar to "Flip," "Banner" is the only turtle with a spinal injury. The greatest portion of his time budget consisted of edge swimming (46.5%), defined as swimming directly toward the wall of the enclosure and running into it. "Banner" spent 25.7% of his time hovering, so a majority of his activity while swimming was directed towards the enclosure walls. Edge swimming was also displayed by "Shelldon" and "Pistachio," but only at 2.3% and 1.1%, respectively. Warwick (1990) states that interactions with enclosure boundaries in reptiles may be due to environmental inefficiencies and/or the inability to recognize a boundary as impenetrable.

The smaller enclosures, ranging from 500- to 1500-gallons, had a source of running water coming from directly above. Another unique aspect of "Banner's" time budget was that he spent 11.0% of his time swimming under the running water on the surface. "Shelldon" and "Pistachio" also displayed this behavior, but only at 1.8% or less. Similarly to "Flip," "Banner" has damage to his carapace and since he did not have rocks to rub on, it is a possibility that the running water provided stimulation to his carapace injuries. Due to his spinal injury and buoyancy control issue, it may be difficult to safely provide environmental enrichment; the running water from above could potentially be a compromise to keep “Banner” satisfied. An example of a special-needs sea turtle who received specific enrichment exists in Therrien’s 2007 study; a blind turtle was given a PVC tube feeder and direct tactile stimulation from an aquarium employee.

4.2 Comparative behavioral analysis

The first hypothesis for this study stated that the five sea turtles would spend more time active in the evening than in the morning. Following use of the Mann-Whitney U test, the hypothesis was rejected (Figure 7). Active behaviors included all behaviors with the exception of two resting behaviors, sleep and awake. On average, the turtles were more active in the morning (51.4%) than in the evening (42.3%). These results do not corroborate this trend within the literature on turtle behavior in the wild. A study by Eckert et al. (1989) used remote time-depth recorders to determine that Leatherback sea turtles (*Dermochelys coriacea*) spent a majority of their time submerged at dawn. Throughout the day, *D. coriacea* had shorter and shallower dives. It is important to note that I did not observe Leatherback turtles for the current study.

The same study by Eckert et al. (1989) can also be used to compare the results of the second hypothesis. When comparing the number of times respiring, it was hypothesized that turtles would also spend more time respiring in the evening than in the morning. The act of respiring can go hand in hand with the level of activity due to sea turtles coming up for air less often when deeply submerged for rest. This hypothesis was also rejected. Figure 8 displays that only two of the turtles, “Banner” and “Ludwig,” spent more time respiring in the evening than in the morning. Houghton, Woolmer, and Hayes (2000) determined that *C. caretta* and *C. mydas* surfaced more often for breathing when in shallow waters during foraging due to the smaller lung volumes required to maintain neutral buoyancy at shallow depths. This signifies that even though The Florida Aquarium turtles may not have followed this pattern, wild turtles tend to respire more often during active time, which occurs later in the day.

I hypothesized that the sea turtles of The Florida Aquarium would spend more time swimming in winter than in spring. This was expected as sea turtles in the Gulf of Mexico and the Atlantic Ocean spending winter months foraging in pelagic waters, then returning to coastal habitats for mating and nesting in the summer months (Miller, 1997). Miller (1997) states that nesting occurs in the northern hemisphere from May to October, with peak nesting in July. The Mann-Whitney U result signifies that this hypothesis must also be rejected (Figure 9). It is interesting to note that “Pistachio,” the only Kemp’s Ridley included in this hypothesis, had a drastic decrease of 25.9% from the winter months to the spring months. This could possibly be another sign that she has retained her innate behaviors in managed care, which could lead to her release.

The fourth hypothesis stated that *Chelonia mydas* (“Flip” and “Banner”) would spend significantly more time swimming than *Lepidochelys kempii* (“Ludwig” and “Pistachio”). Considering *C. mydas* migrate across oceans from nesting to foraging sites and *L. kempii* remain in the Gulf of Mexico (Miller, 1997), “Flip” and “Banner” were expected to swim more but this was not the case (Figure 10). The *C. mydas* did have a 12.1% higher average time spent swimming than *L. kempii*. *C. caretta* also migrate longer distances than *L. kempii* in the wild (Miller, 1997), but this could not be tested in this study as “Shelldon” was the only member of *C. caretta* living at The Florida Aquarium.

The lowest p-value of this study came from hypothesizing that sea turtles in larger enclosures would spend more time inactive than those housed in smaller enclosures. As stated previously, Warwick (1990) explains that as a more sedentary order, Chelonians tend to spend more time resting when in a satisfactory environment than other species of reptiles. The results of this study support this claim as sea turtles in larger enclosures have more enriched environments with artificial reefs, other species of cohabitants, and have ample room to swim. Figure 11 clearly shows that all three turtles in large enclosures (90,000- to 300,000- gallons) spent more time sleeping and resting awake than the two turtles in small enclosures (500- to 1500- gallons). In addition, “Flip,” the turtle in the largest enclosure, spent more time grooming than the others which may signify her ability to relax in her environment.

4.3 Limitations

One explanation for insignificant p-values in this study is due to the monumental difference in behaviors between wild sea turtles versus those in managed care. Johannson (2017) states that reptiles, though assumed to be easily adapted to life in managed care, can often have a harder time assimilating due to innate behaviors being more common in their repertoire as sea turtles experience no maternal care after birth (Warwick, 1990). Considering there are no other baseline ethogram time budget studies to compare the sea turtles of The Florida Aquarium with, it is difficult to discern what is “normal behavior” for these species in managed care. Many ethogram studies have addressed other reptiles more commonly kept not only in aquaria, but also in people’s homes, including terrestrial or semi-aquatic turtles. Even these studies are not comparable to the subjects of this study as sea turtles are completely marine and also require larger enclosures.

Another major issue with this study is the sample size of only five sea turtles, which could have led to large p-values. Although small sample sizes are common in ethogram studies, such as Johansson (2017) observing four Vietnamese pond turtles and two McCord's snake-necked turtles, more significant results might have been observed if sea turtles from multiple aquaria were studied. Considering that sea turtles are a protected group, certain permits are required by the Florida Fish and Wildlife Conservation Commission (FWC) in order to include them in research which would have taken more time than allotted for this project. Participation by other aquaria was solicited, but they either chose not to participate or did not have the appropriate permitting. Permitting for the research of sea turtles by the FWC is highly restricted. This is common in endangered animals and explains the small sample sizes of many ethological studies conducted in managed care.

The Florida Aquarium volunteers and employees have a full schedule of caring for multiple residents and rehabilitation individuals. Cleaning and feeding schedules were unpredictable, which led to some observations being interrupted and not standardized enough for the comparative behavioral analysis portion of this study. The first half of this study did not occur on a regular schedule or for a specific observation length, and thus, this data was not able to be statistically compared. Though it served as an important introduction to the observation of the five sea turtles, more data (especially more months of observation for hypothesis three) would have benefitted this study greatly.

Confounding factors are also a limitation with a study such as this, due to each turtle having a unique combination of factors affecting their behaviors such as age, species, enclosure type, time spent in managed care, and reason for being rehabilitated. It is difficult to determine which aspects of the sea turtles' lives contribute to certain behaviors. For example, both "Banner" and "Flip" are *C. mydas* and have buoyancy control issues, but their behavior cannot be directly compared due to "Banner's" spinal condition and the difference in enclosure size between the two turtles.

Human presence may also cause an alteration in behaviors due to the sea turtles relating human presence with feeding time. For example, the turtles in smaller systems would often wake up after hearing me approach for filming. This could have led to an increase in the level of activity for those turtles. Having an automated camera for each turtle's system would be a way to address this issue.

4.4 Future work

There is a crucial need for baseline behavioral studies on as many species in managed care possible, especially those listed on the IUCN Red List as threatened or endangered. Animals other than mammals and birds are rare in behavioral studies, so focus should be aimed towards groups such as reptiles and fish. Studies of this type are important for their ability to detect abnormal behavior that might signify stress or health problems (Warwick et al., 2013). If animal keepers develop time budgets of individuals when they are in an enriched environment and in good health, they will be more likely to recognize when an animal's behavior is out of the ordinary.

Not only could The Florida Aquarium continue an ethogram study on their sea turtles and other organisms, as holders of a sea turtle research permit, employees can expand on sea turtle studies in managed care. Future studies could include physiological data and feeding behavior data that was not considered in this study. For example, cortisol levels could be compared between “Flip” and “Banner” to see if the behavioral differences between them would be reflected in physiological stress responses.

Once baseline time budgets are established, biologists at zoos and aquaria can introduce enrichment that may reduce negative behaviors. Therrien et al. (2013) introduced enrichment into sea turtle enclosures and found that turtles spend less time in repetitive and aggressive behaviors when provided with enrichment. This study used water cooler jugs and PVC pipes with food embedded and water hoses above the enclosures to simulate a waterfall as enrichment.

Although rehabilitation sea turtles such as “Banner” must be kept in smaller and non-enriched environments due to health concerns, a study that introduces simple and safe enrichment devices, such as those by Therrien (2007), could determine if self-destructive behavior, such as edge swimming, could be reduced. Introducing enrichment while conducting an ethogram study would allow researchers to compare the time budget of turtles with and without the enrichment.

Future studies should also include a larger sample size of sea turtles as well as additional species. Including more zoos and aquaria into a study would provide a more comprehensive and statistically significant data set. The data in this study may have resulted in significant differences if the sample size was larger than five sea turtles.

4.5 Conclusions

As the first study of its kind, this research provides a framework for future studies on animals in managed care to establish a baseline ethogram and to test hypotheses relating to the behaviors using the Mann-Whitney U test. As sea turtles are a common habitant and crowd pleaser for aquaria throughout the world, this information can be applied on a broader scale. Although none of the hypotheses could be rejected, the information is still relevant. Trends identified in this study vary as sea turtles in managed care cannot be equally compared to those in the wild. This being said, aquaria should also consider this difference when developing rehabilitation plans and adequate environments for their sea turtles. This study can also contribute greatly to the care of “Flip,” “Shelldon,” “Ludwig,” “Pistachio,” and “Banner” at The Florida Aquarium. As permanent residents, “Flip,” “Shelldon,” and “Ludwig” could be observed in the future using the ethogram created for this study. This may alert their caretakers of any behavioral abnormalities. The time budgets of “Pistachio” and “Banner” can be used to give them a better quality of life while in their rehabilitation. Changes may also indicate readiness to release as well.

Sea turtles reaching sexual maturity and staying alive as long as possible is absolutely vital for these threatened species due to their ability to lay hundreds of eggs throughout their life (Mestre et al., 2014). Aquaria such as The Florida Aquarium play a pivotal role in not only the rehabilitation and release of injured and ill sea turtles, but also in raising public awareness of the ecological importance of these animals. Public awareness can lead to increased donations towards conservation and people taking steps towards living more sustainable lifestyles. This applies to all animals in managed care in

AZA accredited facilities; behavioral studies of animals in managed care can lead to the conservation of threatened species.

Tables

Table 1. Physiological and environmental information of each sea turtle at The Florida Aquarium

TURTLE NAME	SPECIES	SEX	RESIDENT V. REHAB	CONIDITION	ENCLOSURE SIZE (gallons)
"Flip"	Green/ *Chelonia mydas*	Female	Resident	Buoyancy issues, limited use of front flippers	300,000
"Ludwig"	Kemp's Ridley/ *Lepidochelys kempii*	Male	Resident	Prolonged time in managed care, otherwise healthy	90,000
"Pistachio"	Kemp's Ridley/ *Lepidochelys kempii*	Female	Rehab	Boat strike, vision issues	500-1,500
"Banner"	Green/ *Chelonia mydas*	Male	Rehab	Boat strike, buoyancy issues, spinal injury	500-1,500
”Shelldon”	Loggerhead/ *Caretta aaretta*	Male	Rehab to Resident	Entanglement, cold-stunned, damaged esophagus	500-1.500 to 90,000

Table 2. Complete ethogram for baseline ethogram and comparative behavioral analysis for sea turtles at The Florida Aquarium

STATE	EVENT	CODE	DESCRIPTION
Rest	Sleep	S	Resting on a surface with eyes closed
	Awake	A	Resting on a surface with eyes open and possible head movement
Swim	Dive	D	Swimming down the water column
	Surface	SS	Swimming up to the water surface
	Edge swim	ES	Swimming toward edge of enclosure
	Under running water	UW	Swimming under flowing water coming into the enclosure
	Hover	H	Swimming horizontally in the same area of the water column
Respire	Respire	R	At surface of water with head above water
	In between breaths	BB	Remaining at surface between respiration
Crawling	Crawling	C	Movement along substrate using flippers to crawl
Groom	Rub on rocks	RR (L/R)	Using rocks to scratch body (Left or right side)
	Scratch face with flipper	SF	Using flippers to scratch face
Aggression	Toward ray	TR	Directed aggressive behavior toward ray
	Toward shark	TS	Directed aggressive behavior toward nurse shark
	Chasing turtle	CT	Swimming behind another turtle
Unknown	Bite at enclosure	B	Biting at edge of enclosure or substrate
	Mount rock	MR	In mating position on rock in enclosure
Out of sight	Out of sight	O	Turtle is out of camera's view

Figures

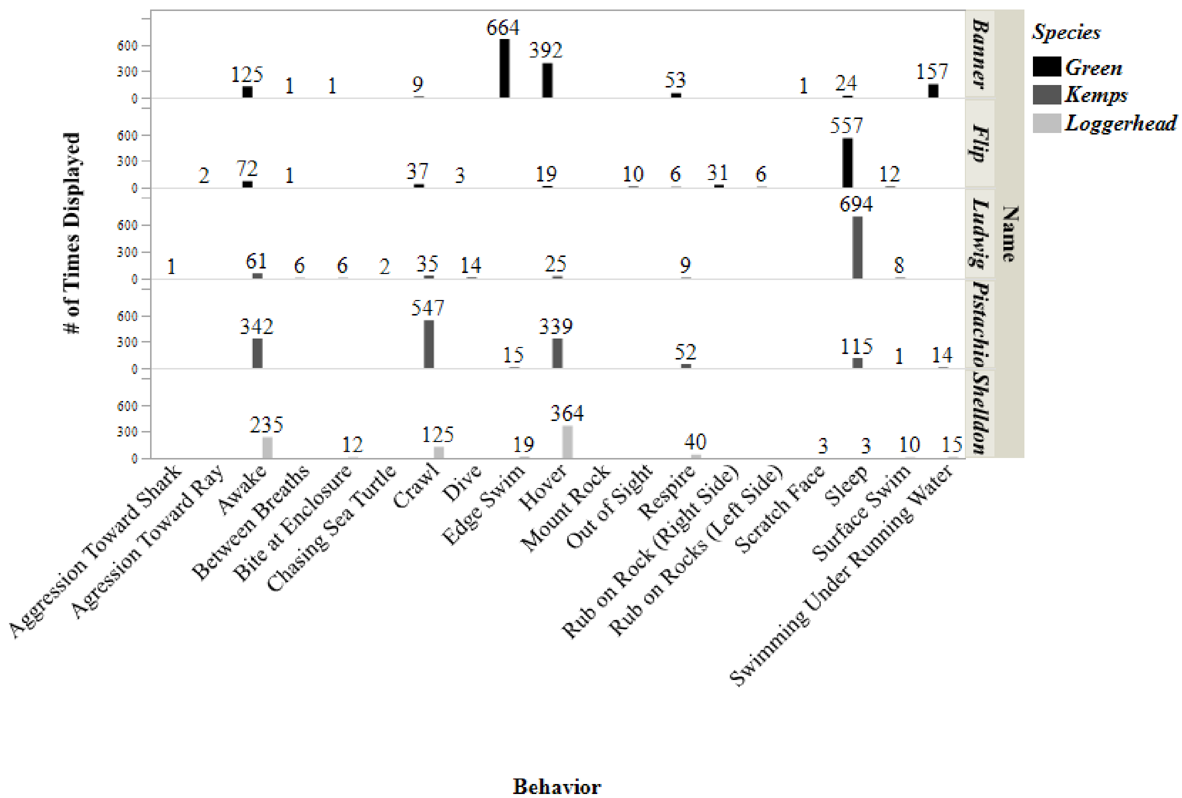

Figure 1. Summary time budget of all 5 sea turtles at The Florida Aquarium. “Shelldon” was the only Loggerhead turtle observed, “Flip” and “Banner” were the two Green turtles, and “Ludwig” and “Pistachio” made up the Kemp’s Ridley turtles. Not all behaviors were displayed by each turtle.

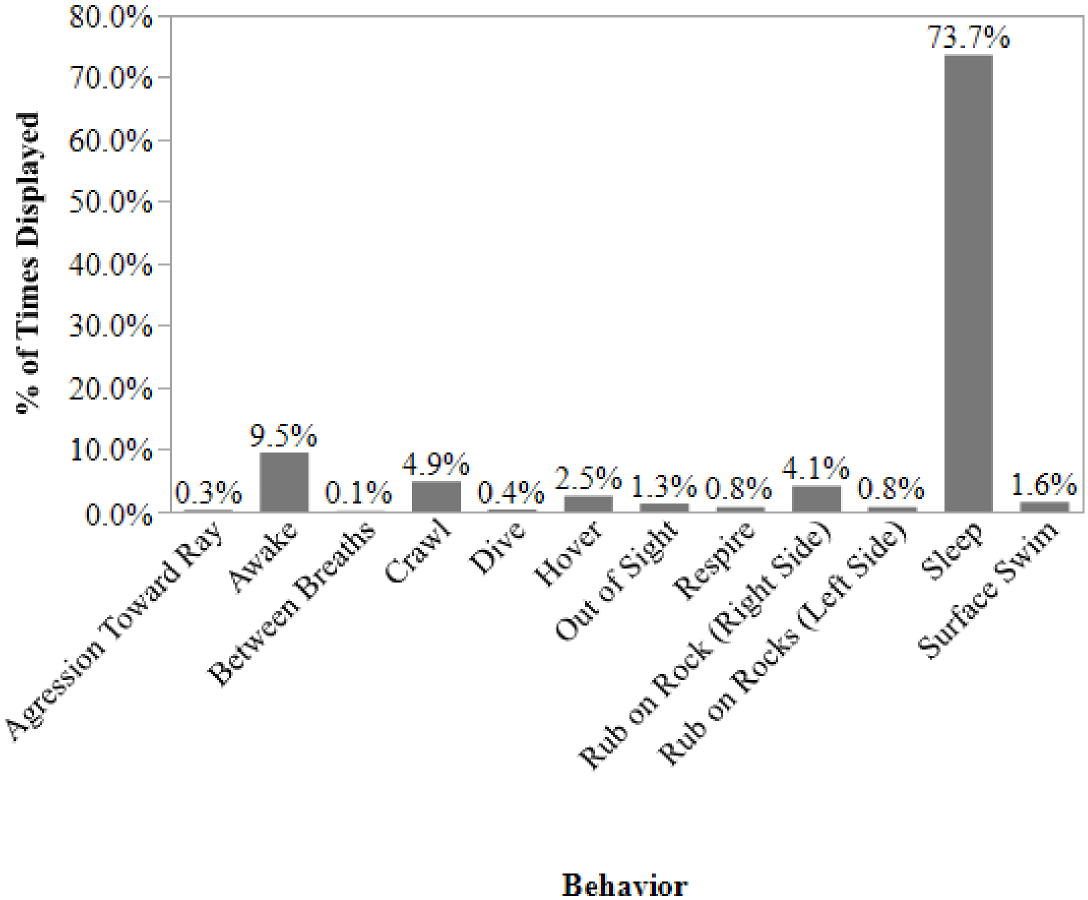

Figure 2. “Flip” (*Chelonia mydas*) time budget.

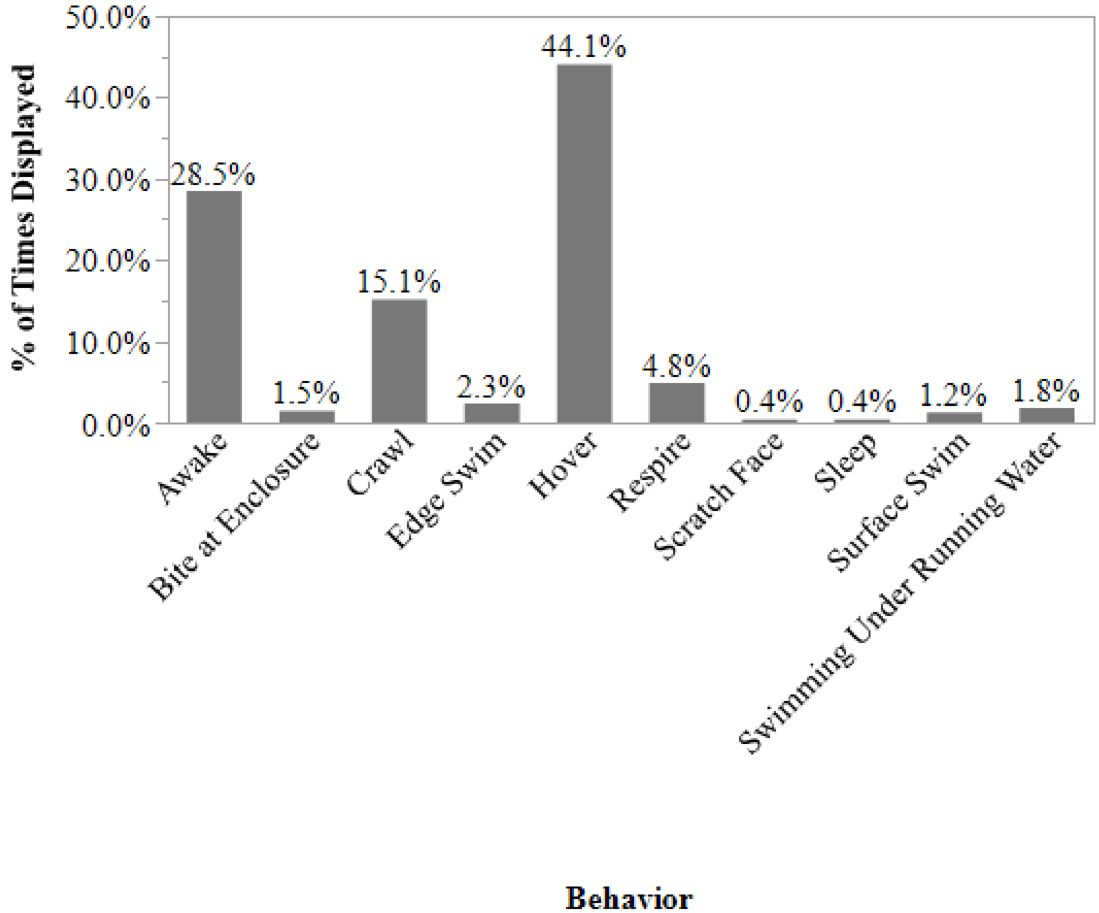

Figure 3. "Shelldon" (*Caretta caretta*) time budget

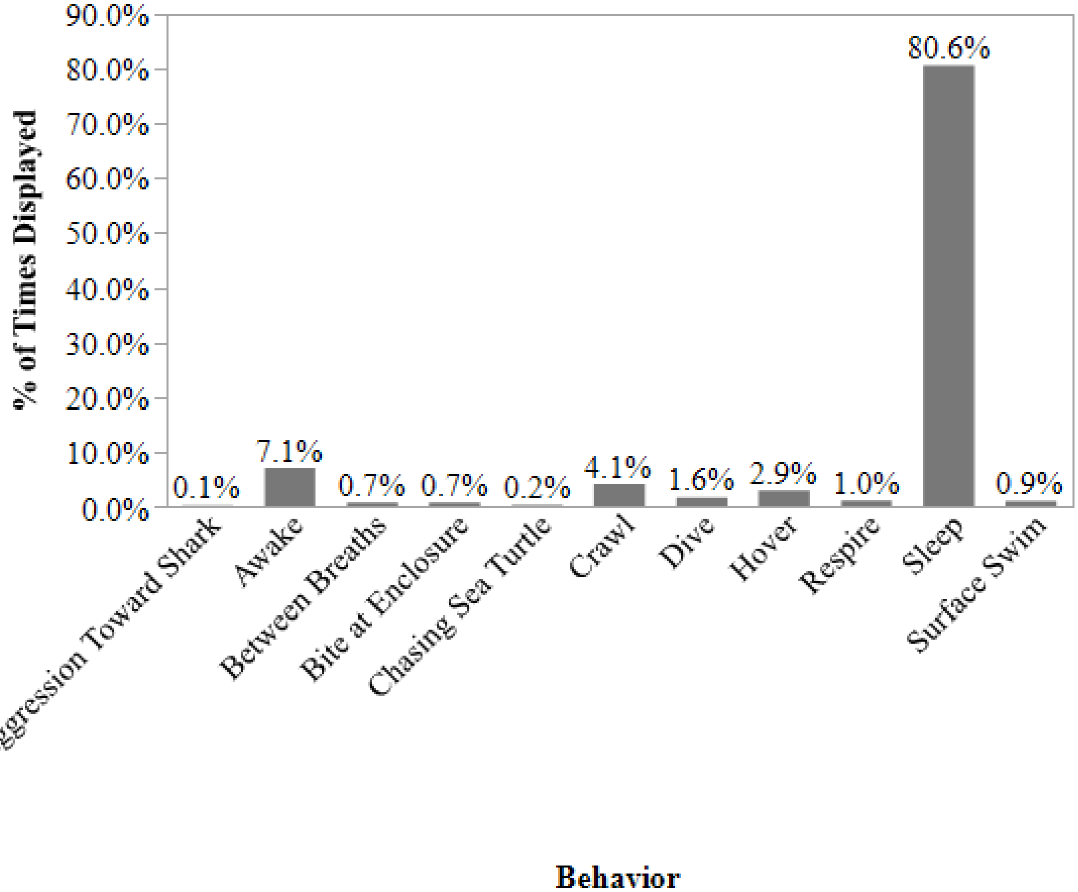

Figure 4. “Ludwig” (*Lepidochelys kempii*) time budget

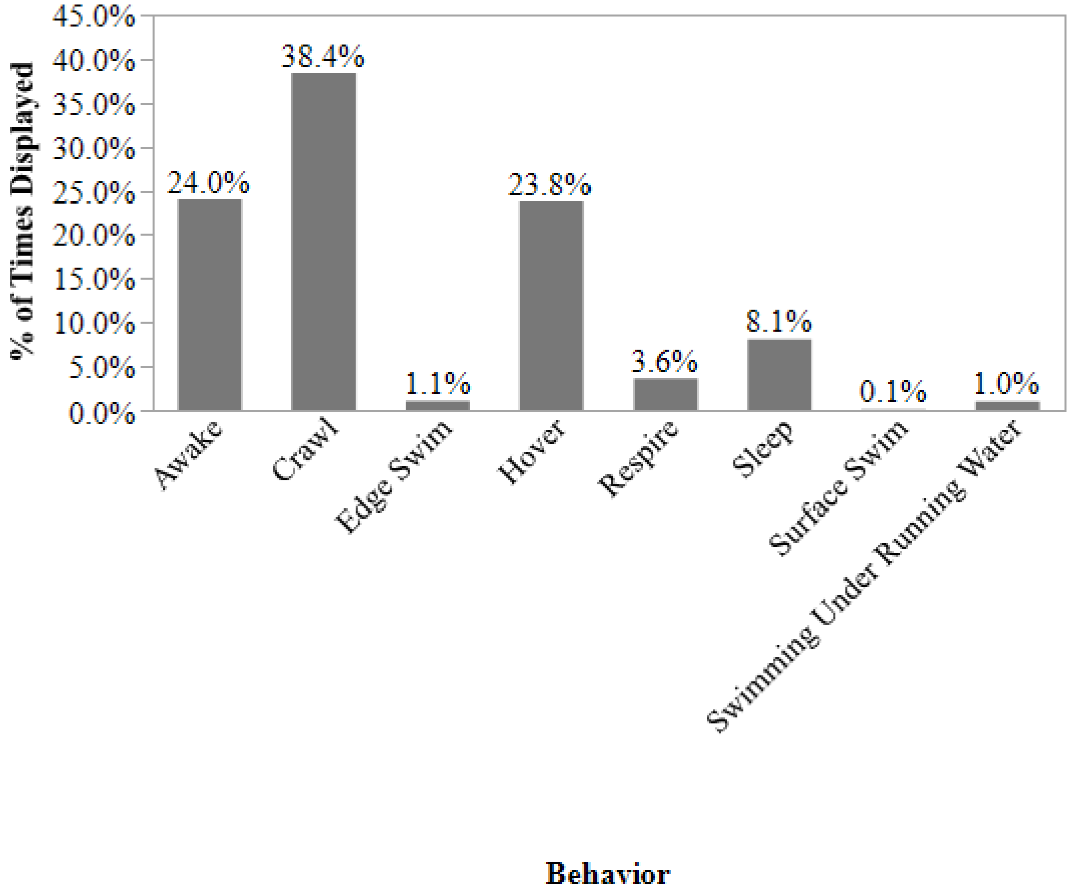

Figure 5. "Pistachio" (*Lepidochelys kempii*) time budget

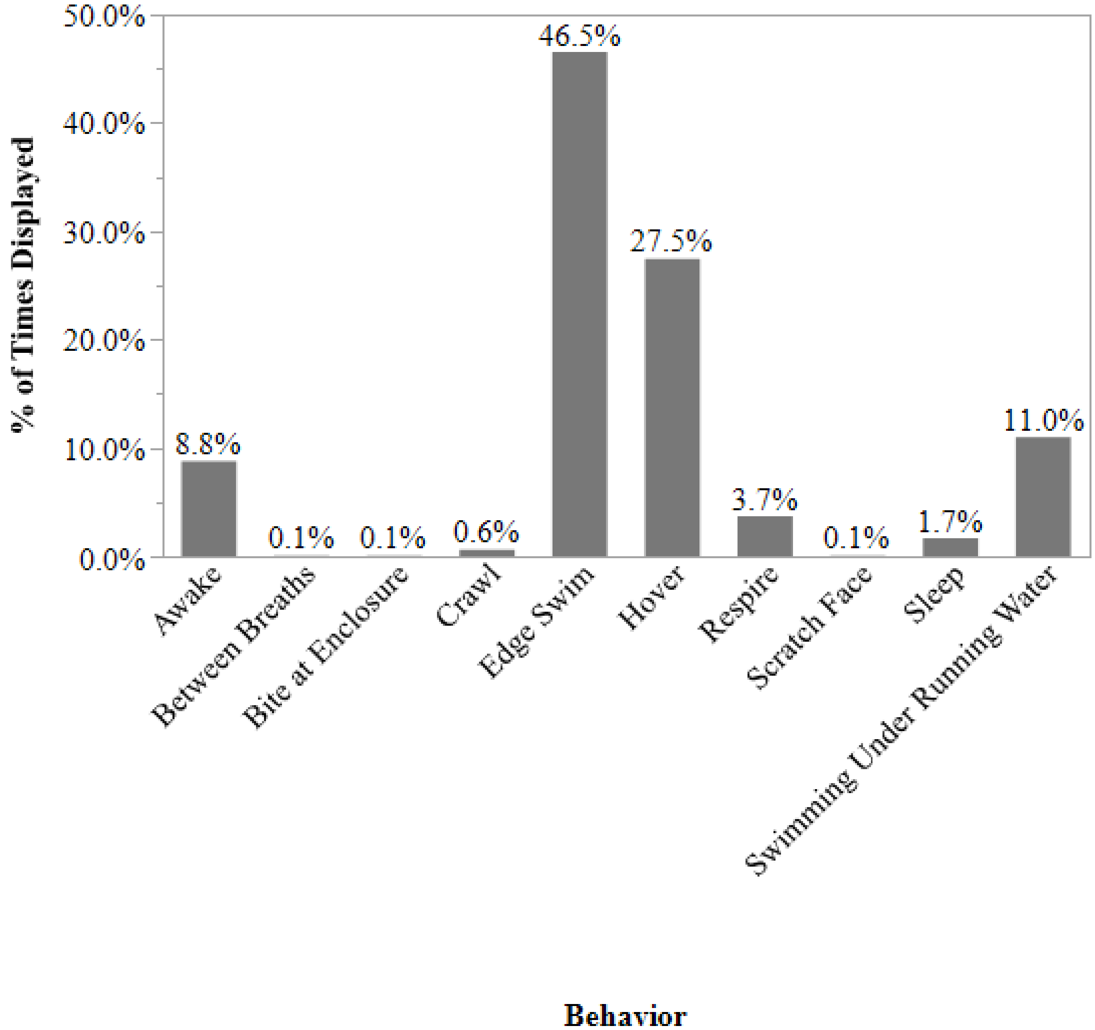

Figure 6. “Banner” (*Chelonia mydas*) time budget

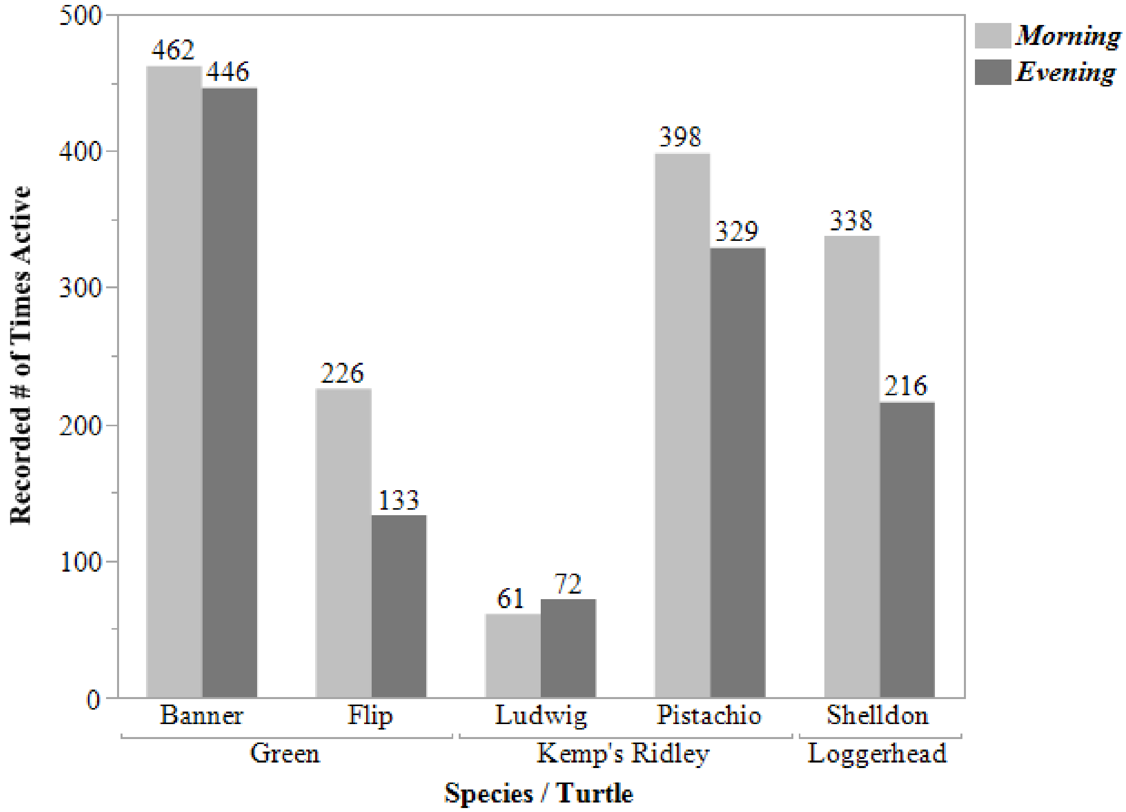

Figure 7. Recorded number of times active v. time of day. No significant difference was found in number of times active between morning and evening (Mann–Whitney U = 9.00, $n_1 = n_2 = 5$, P = 0.465 two-tailed).

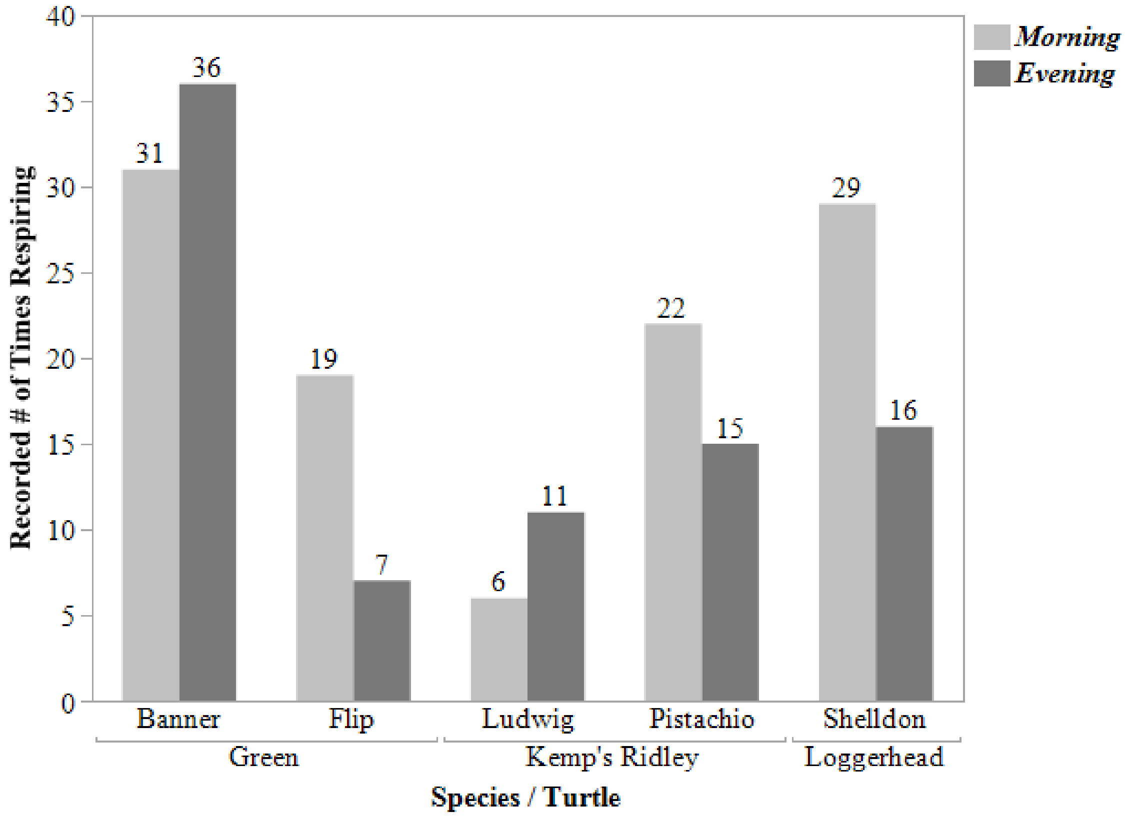

Figure 8. Recorded number of times respiring v. time of day. No significant difference was found in number of times respiring between morning and evening (Mann–Whitney U = 9.50 $n_1 = n_2 = 5$, P = 0.530 two-tailed).

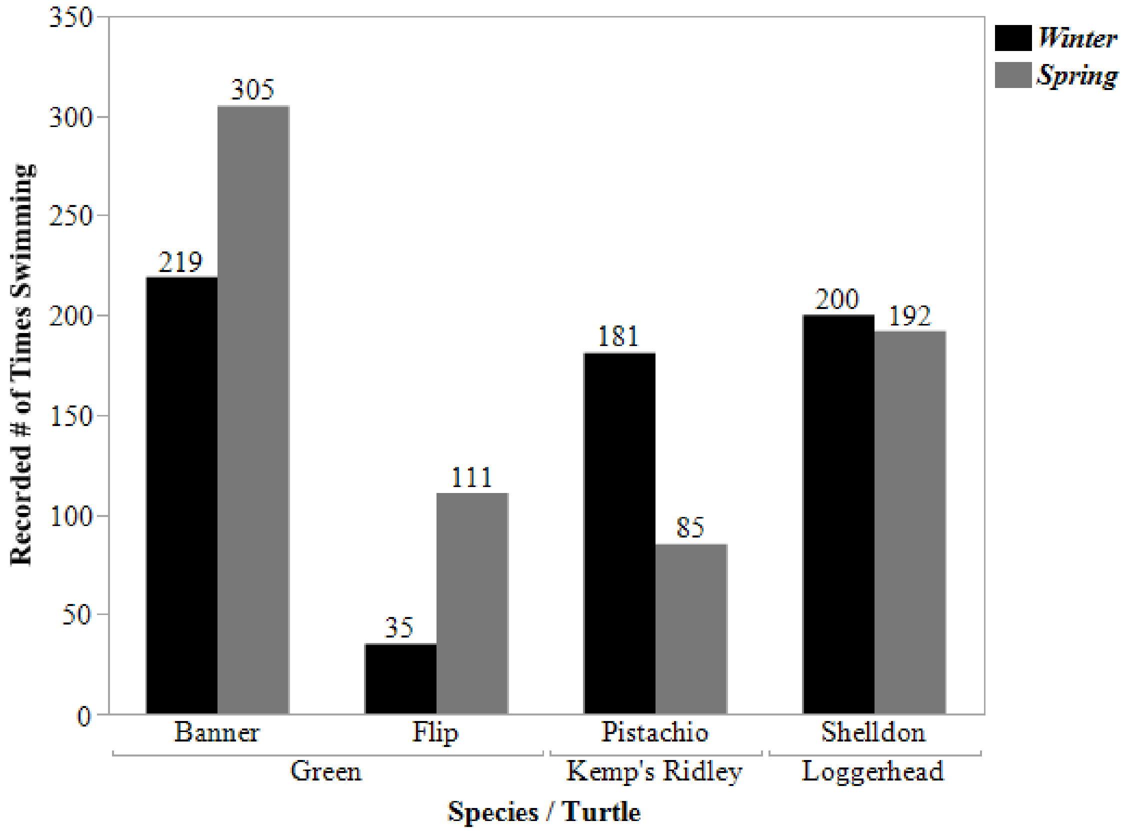

Figure 9. Recorded number of times swimming v. time of year. No significant difference was found in number of times swimming between winter (January and February) and spring months (March, April, and May) (Mann–Whitney U = 6.00, $n_1 = n_2 = 4$, P = 0.564 two-tailed).

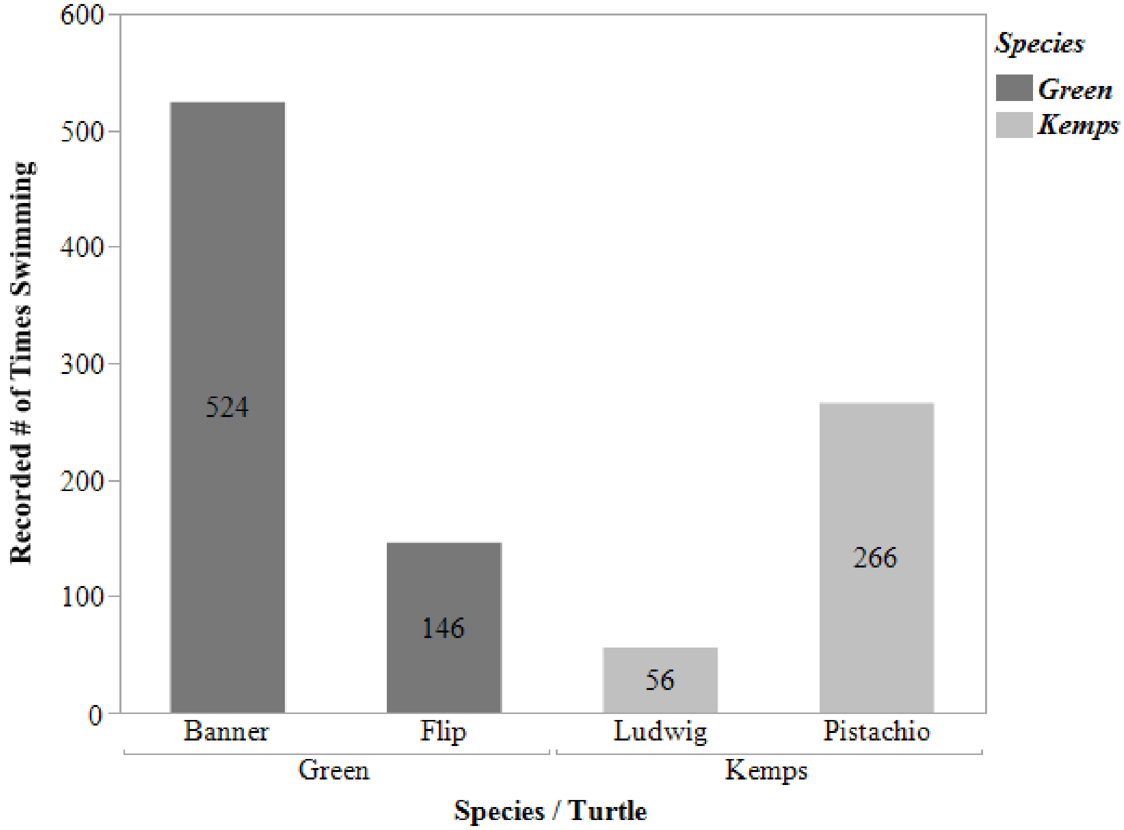

Figure 10. Recorded number of times swimming v. species. No significant difference was found in number of times swimming between Green and Kemp's Ridley sea turtles (Mann–Whitney U = 1.00, n1 = n2 = 2, P = 0.439 two-tailed).

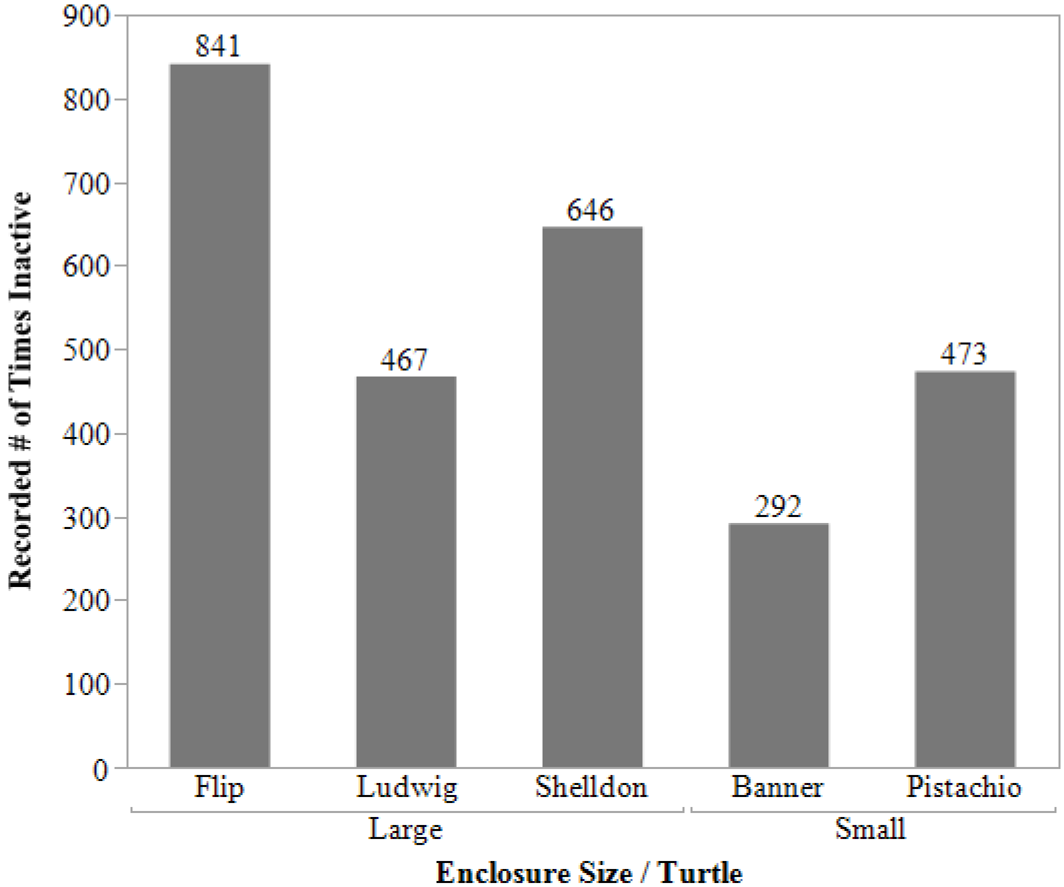

Figure 11. Recorded number of times inactive v. size of enclosure. No significant difference was found in number of times inactive between small (500- to 1500- gallon) and large (90,000+ gallon) enclosures (Mann–Whitney U = 3.00, $n_1 = 3$, $n_2 = 2$, P = 0.083 two-tailed).

List of References

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