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Marine Turtle Health Assessment and Aquarium Suitability: Uzi Island, Zanzibar

Olivia “Warda” Crane

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Abstract

This study assessed the health of the marine turtles in the aquarium on Uzi Island. Health evaluations of each turtle included size, eating habit, and physical abnormalities. Behaviorally the sea turtles were observed at two different time periods multiple times. Results were compared to research on wild sea turtles. The conditions of the aquarium were evaluated for water quality and holding capacity. The water temperature, pH, and salinity levels were tested to assess the water quality. The results showed that the overall health of the sea turtles were positive from the normal activities and few abnormalities. The overall aquarium conditions showed room for improvement from the high water temperatures, low pH values, and dangerous obstacles. Recommendations to address research error and further areas of study were given.
Introduction

The marine turtle has swum the depths of the oceans for over 100 million years existing today as the only reptile to exclusively live in a marine environment, with exception to a few sea snake species (Clark & Khatib 1993; Ripple 1996). Worldwide there are currently eight species of sea turtle, five of these species being found in the Western Indian Ocean. These five include the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys inbricata*), the loggerhead turtle (*Caretta caretta*), the olive ridley turtle (*Lepidochelys olivacea*), and the leatherback turtle (*Dermochelys coriacea*). Numerous amounts of sea turtles used to be found nesting on shore and swimming the oceans but due to both indirect and direct exploitation from human interaction the numbers are quickly dwindling, increasing risk of extinction. All five species are categorized as endangered or critically endangered in IUCN and listed in CITES Appendix I (Convention on International Trade in Endangered Species of Wild Fauna and Flora)(Muir 2005). One specific account was documented in 1973 where 400 green turtles per night would nest on Assumption Island but that number fell to around 100 per year (Frazier 1975). Over time, human influence has negatively affected the sea turtle directly and indirectly. This study will take a close look at the human-sea turtle relationship, what is being done, and the effectiveness of these actions, specifically in the Uzi Aquarium in Zanzibar, Tanzania.

Indirect human interactions with the sea turtle are putting large amounts of stress on the current populations leading to endangerment. Hotel construction on the beachfront property is disturbing the nesting area for the turtles. The preliminary study: *Sea Turtle in Zanzibar* from Fiona Clark and Asha Ali Khatib found that the hotels create a problem from the lights and increased human activity (1993). The female sea turtles struggle to lay their eggs above the high water mark because of the inefficient ability of marine turtles to move on land. This difficulty
makes the darkness of the night necessary to protect from the sun and predators (Ripple 1996). The lights and human activity scare the female turtles away leaving them with having to find a new area to lay their eggs. The lights are also a problem for the hatchlings that emerge in the night and follow the light which is usually the moon on the ocean, but with hotel lighting the new hatchlings may head in the wrong direction and result in death from exhaustion, dehydration, or predation (Clark & Khaatib 1993; Ripple 1996). The depletion of coral reefs and seagrass beds which are used as feeding grounds for sea turtles are destroyed from pollution and destructive fishing techniques such as dynamite fishing and the dragging of nets. Nets can also be dangerous when sea turtles get entangled and seriously injured. Indirectly coastal erosion puts a negative toll on the sea turtle habitats and nesting grounds. Coastal erosion may result from mining, mangrove deforestation, destruction of coral reef, construction on the shoreline, or natural causes, causing a loss of suitable nesting habitat (Clark & Khatib 1993).

Sea turtles are directly exploited for various uses including: food, income, turtle products, turtle shell, turtle shell products, and the sale of live turtles. Turtle meat and their eggs are a high source of protein and can provide a source of income. Coastal populations find sea turtle meat enjoyable and preferred over fish or other meat (Clark & Khatib 1993). Other turtle products such as oil, skin, shell, and internal organs are thought to have medicinal properties and used to treat anemia, asthma, other chest problems, skin problems, diseases causing the urination of blood, and a number of child diseases (Clark & Khatib 1993). The turtle shell is internationally sold for its beauty and use in jewelry.

In this study the green turtle and the hawksbill turtle were looked at due to their current presence in the Uzi Aquarium. The green turtle resides in tropical and warm temperate seas, migrating across the open ocean and foraging in shallow areas with abundant vegetation such as
seagrass beds. They are one of the two most common sea turtles to be found along the East African coast (Richmond 2011). The green turtle is fairly large, growing to about 90-120cm in carapace length and 65-125kg in weight (Ripple 1996). The green turtle is the only herbivorous species and has a serrated horny jaw covering for grazing (Spawls et al 2002; Ripple 1996; Richmond 2011). The green turtle may be found resting along the surface or along the shore basking in the sun due to the lack of vitamin D (Spawls et al 2002). The smooth carapace can vary from green, brown, black, or gray with darker sections (Spawls et al 2002; Richmond 2011). The male has a more prominent and longer tail that extends past the carapace (Richmond 2011). Sexual maturity is not reached until an average age of 10 to 15 years of age (Spawls et al 2002). One act of green turtle exploitation was seen in Europa where 20,000 green turtle hatchlings were transferred to the market (Hughes 1991).

The hawksbill turtle is the other common inhabitant along the East African coast. This turtle tends to occupy shallow coastal waters such as bays, mangroves, estuaries, coral reefs, and rocky areas (Ripple 1996; Richmond 2011). The name comes from the prominent hooked beak that helps with the mature hawksbill’s carnivorous diet of sponges, jellyfish, corals, sea urchins, fish, and molluscs (Spawls et al 2002; Richmond 2011). The hawksbill is relatively small ranging from 76-91cm in carapace length and 40-60kg in weight (Spawls et al 2002). The carapace has dark amber with brown or black streaks seen on the overlapping scales that create a serrated edge. Sexual maturity is younger for the Hawksbill at 8 to 10 years old (Spawls et al 2002). One example of exploitation in hawksbill populations was in 1986 when Japan imported shells from 26,000 large hawksbills and 8,000 small stuffed hawksbills (Howell 1993).

All the indirect and direct stress put on the sea turtle populations results in a need for conservation because of their important roles in the ocean ecosystem. Sea turtles help with the
maintenance of healthy seagrass beds and coral reefs, and helping to balance the marine food webs along with nutrient cycling (Wilson et al 2013). The green turtle’s constant grazing of seagrass beds halts overgrowth which would obstruct currents, create large decomposition grounds, and create habitats for slime mold (Wilson et al 2013). The sea turtles forage the same plot taking from a few centimeters from the bottom and removing the seagrass causing a 15-fold decrease in the supply of nitrogen to the roots which impacts different plant species, the nutrient cycling, animal densities, and predator-prey relationships (Wilson et al 2013). The carnivorous diet of the hawksbill turtle results in the maintenance of a healthy coral reef. The hawksbill turtle is known to feed on sponges and urchins allowing different species to occupy a reef and coral to thrive (Wilson et al 2013; Spawls et al 2002). Healthy shorelines are maintained from the nesting on shore done by the sea turtle. The unhatched sea turtle eggs provide nutrients to the dune ecosystems such as nitrogen, phosphorous, and potassium allowing for vegetation growth and beach dune stabilization, while keeping their nesting habitat healthy (Wilson et al 2013). The extinction of this vital creature would result in the declined health of the ocean ecosystems.

The need for conservation is apparent but limited from inadequate knowledge about the sea turtle life cycles, migration patterns, and ecological relationships (Ehrenfeld 1995). Several techniques are available for the conservation of the marine turtle and at the minimum require a level of protection to be established. The protection of nesting beaches, feeding grounds, and aquatic habitats are areas that if successfully protected with enforcement would help increase turtle populations (Ehrenfeld 1995). To establish that protection local education would have to be implemented along with a disciplinary system. Development of new devices to yield a reduced accidental catch of sea turtles in fishing nets should be implemented. For instance, increasing the use of TEDs (Turtle Excluder Devices), a grid placed in shrimp nets that allows for debris,
turtles, and other large marine organisms to escape (Ripple 1996). Aquariums for rehabilitation can play a vital role for the sea turtle by the establishment of a safe haven for fishermen to surrender injured or caught turtles that can undergo a healing period followed by replacement back into the wild. A small aquarium may also be used for the benefit of educating a community. Raising hatchlings and captive breeding have not shown positive results because removing hatchlings takes them away from unknown experiences and captive breeding has the lack of natural selection and tendency for rapid destructive change which are not evolutionarily conducive (Ehrenfeld 1995; Ripple 1996).

The importance of conservation of the marine turtle is necessary to help protect this endangered reptile. Rehabilitation sites can provide captured sea turtles a safe place to heal. To adequately provide a rehabilitation and conservation center the status of the aquarium must be of an adequate level to ensure sea turtle health. This study evaluated the health of the marine turtles in the Uzi aquarium to determine if adequate health was present and appropriate care provided. The suitability of the aquarium was also evaluated to determine the sustainability of the aquarium. Recommendations have been provided for improvements for optimal sea turtle health.
Study Area

_Uzi Island_

Uzi Island is located on the south western most tip of Unguja, the main island in the Zanzibar archipelago (Figure 1). It is approximately 35 kilometers from Stone Town. Uzi Island is connected by one single, three kilometer, coral rock road through the mangroves which is only above water during low tide. The island has an estimated population of 7000 people who largely depend on fishing, agriculture, and aquaculture as a means of livelihood (Aliy 2013). This is resulting in a depletion of the natural resources available. The villages still practice the killing and eating of sea turtles (Aliy 2013).

_Uzi Marine Turtle Aquarium_

Located two kilometers west from the center of the village, Uzi Mbau, is a recently man made lagoon aquarium. The journey to the aquarium requires a ten minute bike ride on a coral rag, dirt, and sand path followed by a five minute walk over, over grown vegetation and an abundance of coral rock. The aquarium is located within a mangrove containing large amounts of coral rag. The aquarium was initiated with help from World Unite in October of 2010 and has under gone and is still in the process of construction including a concrete boardwalk through the aquarium and current excavating to deepen and enlarge the lagoon area (Aliy 2013). Currently the aquarium has two main ponds connected through a small tunnel. During spring tide an increase of water allows for an extension of each pond to open. The need for an aquarium was thought necessary to be a rescue sight for the sea turtles that are often caught in fishing nets and to show conservation efforts on Uzi (Aliy: Interview 2013). The alternative would be death as they would either be sold and/or eaten (Aliy: Interview 2013).
Figure 1: Map of Unguja Island, Zanzibar with Uzi Island marked by a star* (East Africa Adventure Company 2008).
Methodology

Aquarium Suitability

In the fifteen day field study, examination of the aquarium was conducted to determine suitability. Suitability was determined through water quality and lagoon size. Water quality was tested from pH and salinity levels along with temperature; all taken for both low and high tide in neap and spring tide. The pH and salinity were determined with use of universal pH paper and a refractometer. The size of the aquarium for holding capacity analysis was determined through basic area and volume formulas (A=lxW; V=lxWxH). Measurements were taken with a tape measure. The change in water level from low to high tide during neap and spring tide was taken using a tape measure. Visibility analysis was done from observations.

Aquarium Background

Qualitative information was gathered from an interview with Aliy Abdurahim Aliy, wildlife officer and head of Uzi Marine Turtle Aquarium. General questions about the history of the aquarium, conservation efforts, and admittance of turtles were asked (Appendix 1).

Turtle Health

In the fifteen day field study, the health of the six (two hawksbill, four green turtles) sea turtles were evaluated from physical and behavioral observations. The basic health examination included feeding schedule and diet, size, and bodily abnormalities. Each turtle was attempted to be individually and identically examined to determine health conditions. Size was taken from carapace length using a measuring tape. If the turtle was not able to be caught, a stick was held up to the turtle at the surface to determine carapace length. Behavioral observations were collected twice daily (morning and afternoon). The observations were 30 minutes in duration and multiple were taken during each visit. In each observation period the number of breaths taken,
the amount ate from counting each time a turtle took a bite, swimming, resting, and non visible times were recorded. The data was compiled and compared to research on wild sea turtles to determine if normal health and behavior was present.
Results

Aquarium suitability

The aquarium contains two lagoons that are connected through a small channel. Pond 1 had an area of 122,400 cm$^2$ with a depth of 71 cm at lowest tide and a depth of 185.1 cm at highest tide (Appendix 3; Picture 1). Pond 2 had an area of 106,600 cm$^2$ and a depth of 81 cm at lowest tide increasing to 195.1 cm at highest tide (Appendix 3; Picture 2). The pond 1 extension had an area of 79,800 cm$^2$ and a depth of 43 cm with a volume of 3,431,400 cm$^3$. Total carapace length was 216.57 cm (Appendix 2; Table 3). No water variation was seen from low to high tides during neap tides. Some seawater was circulated during spring high tides due to the pipes in the concrete board walk (Appendix 3; Picture 3).

The water quality measurements (temperature, pH, and salinity) were taken for each low and high tide during neap and spring tides. A higher temperature for neap and spring tides was during high tide ($31 \pm 0.71^\circ C$ neap high tide; $32.667 \pm 1.53^\circ C$ spring high tide)(Appendix 2; Table 1). The highest pH level was at spring high tide of $6.333 \pm 0.58$ and the lowest was at neap high tide $5.25 \pm 0.35$ (Appendix 2; Table 1). Spring low tide has the lowest salinity level of $27.875 \pm 1.44‰$ and neap low tide had the highest of $30 \pm 0‰$ (Appendix 2; Table 1). The visibility conditions of the lagoon were murky during each tide and the bottom was never visible. During spring high tide a layer of oily scum and debris formed on the surface (Appendix 3; Picture 4). The rain made the water highly muddy and cloudy.

Each pond was observed for the amount of shade coverage provided at a morning time (10 am) and afternoon time (3 pm)(Appendix 2; Table 2). The two ponds were further broken down into the extended areas during spring tide. As seen in appendix 2: table, 2 ponds 1, 1E, and 1C had higher amounts of shade coverage in the morning of 70%, 50%, and 100% while pond 2...
was 10% shade. In the afternoon pond 1 had a decrease in shade coverage to 35% while both extension areas increased to 100% (Appendix 2; Table 2). Pond 2 had an overall increase in shade from 10% to 20% and for the extension area 10% to 60% (Appendix 2; Table 2).

Dangers in the aquarium consisted of the jagged coral rock, pipes through the pond, and the shallow extensions. Turtle B was observed to be stuck on top of the pipe present in pond 1, struggling lasted for approximately 30 seconds before the turtle was able to free itself. Turtle B was also found stranded on the mud in the pond 1 extension during neap low tide where water was no longer present from the tide escaping too fast.

Aquarium Background

From the interview in appendix 1 with Aliy Abdurahim Aliy, it was found that the aquarium was initiated in 2010 with support from World Unit to bring conservation efforts to Uzi, a rehabilitation site for the accidental catchment of turtles, and hope to generate money from ecotourism for the community (2013). The current group of turtles is the second group to live at the aquarium because the first group of turtles were either released by a specialist or if sick sent to Mnarani Turtle Aquarium. The current group are from September-November 2012 and all but one, were turned in by fisherman from accidental catch in gill nets. One hawksbill was the result of a fisherman diving into catch the sleeping turtle. A small amount of money and conservational talk is given in exchange for the turtle.

Individual Turtle Health

The aquarium housed six marine turtles, four green turtles and two hawksbill turtles.

Turtle A was the largest green turtle with a carapace length of 62.17cm. The carapace coverage by mud never exceeded 90% and had a 10cm white scrape on the second vertebral
scale (Appendix 2; Table 3). A blue/green barnacle, approximately 2cm in diameter, was present on the top of the head.

Comparatively turtle B was the medium sized green turtle with a carapace length of 42.6cm (Appendix 2; Table 3). The mud coverage on the carapace was the lowest, never exceeding 40% while multiple scrapes were observed on the outer edges of the carapace scales (Appendix 2; Table 3). Small discoloration of gray was present on the back right flipper. White crud took up residence in the eye corners.

Turtle C was the smallest turtle and the smallest green turtle with a carapace length of 35cm (Appendix 2; Table 3). The carapace mud coverage never exceeded 60% and three small sections along the 4th vertebral scale were missing (Appendix 2; Table 3; Appendix 3; Picture 5). A small section of the back left flipper was missing forming a jagged edge. The eyes also contained white crud in the corners.

Turtles D and E were two undistinguishable hawksbill turtles whom never surfaced at the same time to result in combined observations. The carapace length was approximately 38.4 cm with a mud coverage never exceeding 95% (Appendix 2; Table 3). The right costal (C3) scale had two small white circle markings. No other abnormalities were observed.

Turtle F was a green turtle that was found to be deceased on the first day of field observations (Appendix 2; Table 3). The turtle was found vertically, head first stuck in the mud located through the connecting channel of the two ponds and in the channel entrance to the pond 1 cave extension.

**Turtle Behavior**

Turtle behavior was observed during both feeding time and non-feeding time. No apparent feeding schedule was witnessed and inconsistent times along with food amounts were
observed. The food was collected from the beach shore and identified as seaweed species: *Cladophoropsis sundanensis* Reinbold, *Sargassum oligocystum* Montagne, *Sargassum cristaefolum* C. Agardh and seagrass species: *Thalassodendron ciliatum* (Forskål) den Hartog, *Sesuvium portulacastrum* L. (Richmond 2011)(Appendix 3; Photo 6). A bucket, two buckets, or a handful were dumped in all at once. Organisms in the pond consisted of numerous crabs, approximately 4 different schools (containing 10-20 fish) of juvenile fish, and juvenile shrimp.

For each turtle the individual time spent breathing, eating, swimming, resting, and nonvisible varied. During feeding time turtle A and C had similar percentages of activity except for the percent of time spent resting and in a nonvisible state for 1-5mins (Figure 1). Turtle D/E was only seen taking breaths, swimming for less than 1 minute, or eating during feeding times (Figure 1). Turtle B spent the highest percentage of time resting for 1-5mins (Figure 1). During non-feeding time percentage seen taking a breath increased for every turtle (A, B, C, D/E) (Figure 2). Eating percentages decreased from feeding time to non-feeding time (Figure 2).

![Figure 1](image1.png)

*Figure 1.* The percent of each turtle spotted performing a given activity per 30 minute observation during feeding time.

![Figure 2](image2.png)

*Figure 2.* The percent of each turtle spotted performing a given activity per 30 minute observation during non-feeding time.
The green turtles in the aquarium had a more visibly active behavior during feeding and non-feeding times. The green turtles spent $12 \pm .16\%$ and $11 \pm .12\%$ of the time swimming for 1-5mins compared to the hawksbill’s $0\%$ (Figure 3). The hawksbill was only seen swimming for less than a minute, $8\%$ and $11\%$ of the time (Figure 3). A large percentage was spent eating of $36 \pm 1.4\%$ for the green turtles during feeding time and $20 \pm .87\%$ during non-feeding time (Figure 3; Figure 4). The hawksbill was only seen eating $4\%$ of the time during feeding time. The hawksbill spent a majority, $55\%$, in a nonvisible state during feeding time and increased to $60\%$ during non-feeding periods (Figure 3; Figure 4). The other majority of activity came from surfacing to take a breath of air. The green turtle could be seen $22 \pm .04\%$ and the hawksbill $31\%$ of the time taking a breath during feeding times. Seen in figure 4, breath percentages increased during non-feeding times to $41 \pm .83\%$ for the green turtles and $32\%$ for the hawksbills. During feeding the green turtles spent $5 \pm .61\%$ of time resting for 1-5minutes compared to the hawksbills $0\%$ (Figure 3). Throughout non-feeding times the turtles were seen doing fewer activities (Figure 4).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Combined individual green turtles for a green turtle average to compare with the hawksbill turtle. Percentage of observed time spent participating in various activities per 30minute observation during feeding time.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Combined individual green turtles for a green turtle average to compare with the hawksbill turtle. Percentage of observed time spent participating in various activities per 30minute observation during non-feeding time.}
\end{figure}
No tame behavior was witnessed from the turtles. During physical measurements of turtles B and C, both displayed frightened/struggling behaviors of intensely flapping their flippers. Turtle A easily frightened in the pond as seen by 6 acts of sudden movement to the bottom or in an opposite direction. No signs of aggression were seen during initial feeding time, with delayed reaction to forage for food of approximately 1-2 minutes. One act of aggression was seen of turtle B pushing turtle C with the front right flipper. The turtles were seen eating from the same strand of seaweed 5 times (turtle A with B twice, turtle A with C twice, and turtle A with D/E once). Turtle B and C were seen swimming over top each other twice.
Discussion

Aquarium Suitability

The size requirement of an aquarium is 900cm$^2$ for every 10cm of linear carapace length and with each additional turtle the required size progresses exponentially (Florida 2007). The current aquarium does maintain the required amount of 209,960cm$^2$ but the equation used did not factor in the depth of the aquarium. The added area of ponds 1 and 2 at lowest tide is 229,000cm$^2$. If the water starts to leak out the turtles will quickly be in an overcrowded environment. In crowded environments fungal and bacterial infections are likely to spread fast (George 1996). The carapace width should also be measured for a more accurate calculation. The depth had shallow range of 71cm-195.1cm. Both green and hawksbill turtles are habitants of shallow waters (Spawls et al 2002; Richmond 2011) which is an aspect of the Uzi Aquarium.

In order to maintain an environment for sea turtles to thrive the conditions of the aquarium need to be sufficient because the main threats to aquarium life are temperature, light, water quality, feeding, overcrowding, and poor hygiene inflicted variations (Risley, 1971; Hiebler & Wong 1997). The temperature conditions of the Uzi Aquarium were higher than the optimal ocean temperature range for a sea turtle of 25-30°C (Bluvias & Eckert 2010). The below standard temperature in the aquarium had a lowest temperature of 29 ± .53°C with the highest temperature reaching 32.667 ± 1.53°C (Table 1). Sea turtles are cold-blooded animals meaning that their internal temperature changes with the surrounding temperatures making them highly sensitive to changes in water temperature (Riedman & Witham 1974). The changes in seawater temperature may have harmful effects such as cold stunning, decrease/increase in activity, and even death because it changes the reaction rate within their cells (Anderson 2008). Shaded areas help with decreasing the water temperature but the high temperatures suggest that more shade is
necessary. Additional shade limiting the amount of direct sunlight can reduce the possibility of sunburn, lower water temperature, and inhibit algae growth (Bluvias & Eckert 2010). Along with temperature another component of water quality is the pH level. The typical pH of the ocean and sea turtle environment should be 7.5-8.5 (Florida 2007). The collected pH was on average 1.62 levels below the pH of 7.5 and was never in the optimal range (Table 1). In the ocean, pH is usually a stable level due to the ocean’s excellent buffering system between carbon dioxide and water so variations out of normal range may lead to marine death (Anderson 2008). The last water quality tested was salinity. The range of salinity for sea turtles should be 20-35‰ (Florida 2007). The salinity of the Uzi aquarium fell in a sufficient range of 27 ± .875‰ – 30 ± 0‰. The results showed that optimal temperature and pH ranges were not facilitated at the Uzi aquarium. This was seen due to the lack of ability to completely circulate water like the open ocean which results in evaporation of fresh water and ground absorption.

Muddy and murky water conditions subjected the turtles to live and swim in cloudy waters that can have harmful health effects. Poor water quality may lead to the declined health of captive sea turtles because of the increased ability to develop bacterial infection (George 1996). Again this result may be due to the lack of complete water circulation as the pipes are located high on the boardwalk just letting in the top layers of water along with the layer of oily silt, and debris. Swimming in these contaminated waters may result in skin and eye problems along with increased infection potential (Kennedy 2013). Another existing problem that may surface is fibropapillomatosis which is a disease of soft tissue tumors specific to sea turtles. This disease is more prevalent in warm waters and a problem of poor water turnover (Mitchell 2013). Though extreme health diseases were not observed of the sea turtles in the Uzi aquarium long term exposure may induce such problems.
The dangers within the aquarium contribute to the unsuitability of the aquarium. The pipe poses a stranding potential on the turtles if they are to get stuck on it as seen with turtle B. The coral rag is also a danger as seen with the incident of turtle F’s death. The issue of the tide coming in and out too fast has resulted in pond extensions that lose all water coverage as observed with the stranding of turtle B on land. These issues make for an unsafe environment for the turtles at this time but with continued construction hazards may be resolved. In the wild the turtles would be able to forage in different areas and not be restricted to an unsafe habitat.

Aquarium Background

The start of the aquarium was supported by World Unit whom is no longer in connection with the Uzi Aquarium. The first group of turtles was unsuccessful due to the inability of the aquarium to hold water and care for sick turtles. The aquarium now holds water through neap low tide other conditions of the aquarium should be meet standards (temperature, pH, salinity, size, care takers) before bringing in turtles or starting new projects. The act of paying for the turtles is a sensitive issue because the creation of a market may result. Due to the focus of this project many aspects of fisherman and the community interaction with turtles were not researched. Great ideas for ecotourism and rehabilitation site were discussed but the main goal needs to be ensuring the turtles are in the best health as possible. The current aquarium should focus on finishing the construction of the aquarium and fixing the observed down falls before turtles are allowed in, to avoid accidental deaths. Taking one step at a time and finding support will ensure the aquarium to be finished and suitable for turtles. It is after that time that an educational, ecotourism program may be developed because of its ability to enhance conservation actions and create attachments to the species being conserved (Murray 1997).
Individual Turtle Health

The results of the individual turtle health show an overall positive evaluation of turtle health. The carapace marks were limited and are not a major concern because no whole scales were missing and bleeding was not present. The marks could have occurred from the small parameters and scraping along the coral rag. The flipper conditions observed are areas that should be watched and regulated. Turtle B’s flipper discoloring could potentially turn into a more severe disease such as gray patch disease; a common disease with captive sea turtles (Brennan 2011). Turtle C’s missing flipper section may have been a result of entanglement in a net or catching within an obstacle. It seemed to be healed and did not affect activity. The barnacle present on turtle A is a concern and if increases could obstruct vision. Barnacles have been found to increase and cause shell erosion along with fatal injuries (Seigel 1983). The white crud in the eye corners of turtle B and C might have come from the secretion of salt from the eye gland or potentially the start of a more serious disease, fibropapillomatosis, and should be observed daily. The mud coverage did not seem to inflict harm on the turtles but is a sign of poor water conditions and circulation. Full physical examinations of each turtle were not possible due to the lack of assistance and qualified guides. This lack discredits concrete health conclusions but with full examinations better health conditions of each sea turtle could be determined.

Turtle Behavior

The vegetation given at feeding was adequate but the amounts were not calculated and inconsistent. For captive living where live vegetation is not available to the sea turtles amounts fed should be calculated by the weight of each turtle. As described by Jessie Bluvias and Karen Eckert in *Marine Turtle Trauma Response Procedures: A Husbandry Manual*, the adequate
amount of vegetation is a total of 1-5% of the sea turtle body weight on a daily basis and may be fed 1-3 times a day (2010). Developing a daily feeding schedule would help to ensure adequate diets for the sea turtles (Appendix 4). The different seaweed and seagrass species were sufficient in providing variety and correct vegetation for the green turtles. The results showed that all species were consistent of seagrass beds and eulittoral to sublittoral areas where green turtles would forage (Richmond 2011). The feeding of sponges, jellyfish, fish guts, or other organisms was never observed and the aquarium did not house those organisms. This is insufficient for the adult diet of the hawksbill that was seen eating seaweed, an abnormal behavior. Since age of the hawksbill was unidentifiable being able to produce the right diet is unattainable.

The individual activities of the turtles were normal wild behaviors of eating, breathing, swimming, and resting. In *Coldblooded Air Breathers* Riedman and Witham note that one breath of air may be enough to last a sea turtle for up to two hours (1974). The breath percentages observed were much higher than every two hours (Figure 1-4). In Jeff Ripple’s *Sea Turtles*, it was found that shortened breaths may be an effect of increased activity or stress level of the turtle (1996). The high amounts of breathes taken may be a result of the poor water quality increasing the need for oxygen. A lack of ability to draw a concrete conclusion of the oxygen level exists because the oxygen level was not tested. The results show that the green turtle was seen resting or basking for 2-5% of the time, while this behavior was never seen of the hawksbill. The herbivorous diet of the green turtle creates a lack in vitamin D and results in the behavior of the green turtle to rest or bask in the sun (Spawls et al 2002; Hiebler & Wong 1997). Territorial behavior was not observed but turtle B had the highest percentages of resting and seemed to have a preferred spot in pond 1 or 2 extensions. Aggression or territorial acts were never seen when others disturbed turtle B’s resting area. In crowded aquarium life the turtles
may develop territorial behaviors. In Fred Parrish’s study on *Miscellaneous Captive Behaviors* the turtles showed territorial, preferred spots for swimming, resting, and sleeping (1958). The green turtle showed a more visibly active life style when compared to the hawksbill activities. The adult hawksbill is generally found to stay along the bottom of habitats (Ripple 1996; Muir 2006). The tendency to stay in deeper waters was seen by the high percentage of the hawksbill being in a non visible state (Figure 1&2).

Little to no aggressive behaviors were observed. During feeding the results showed that there was not an immediate urgency for the food or aggressive behavior towards the other turtles. Foraging seemed natural and not on a time constraint. The act of aggression that was observed seems to be from the close parameters of the other turtles. This is due to the natural tendency of sea turtles to be solitary animals except when it is time to mate (Defenders 2013). The aquarium forces the five turtles to live in a contained area together.

Source of error in this study came from the lack of ability to identify age, sex, and weight of the turtles along with the lack of full physical analysis, blood testing, and complete water testing. The short time frame of the study contributes to weak averages for neap and spring tides. With more testing further concrete conclusions could be drawn about turtle health and aquarium suitability.
Conclusion

This study was to determine if the Uzi aquarium was exposing the captive sea turtles to inadequate aquarium life: size of aquaria, water quality, and general observations along with analysis of turtle health were collected. This study has shown that the Uzi aquarium is not a suitable environment for the marine turtles at this time. The water was seen to be of poor quality in the areas of inadequate temperature, pH, and clearness. The size of the aquarium will be insufficient with any leakage of water. The obstacles within the aquarium were life threatening. The turtles were observed to be healthy but if subjected to the current aquarium conditions for an extended amount of time a rapid decline in health may occur.

The establishment of a rehabilitation site can be vital to the conservation of sea turtles. A rehabilitation site needs to be in pristine conditions so sick turtles are able to heal and not subjected to poor conditions that will worsen current health. The establishment of an education system for the community is also largely beneficial to the conservation of sea turtles. For the Uzi aquarium to be a successful conservational site the construction and renovation of the aquarium would need to be finished before acquiring sea turtles.
Recommendation

For Future Studies
This study has sparked the potential for many research projects at the Uzi Marine Turtle Aquarium.

- Public awareness: Accessing the awareness of the community on the issue of sea turtles conservation. The local communities are still practicing the eating of turtle meat which may be due to a lack of awareness and education about the endangerment of marine turtles.
- Eating Turtles: Surveying of the community to understand who and why turtles are still being eaten.
- Educational Aspect: The educational aspect of conservation is a vital part and developing an educational program for the Uzi Aquarium would help further sea turtle knowledge. This could include posters/signs for the aquarium, field trips, and activity booklets/curriculum for the local schools and those who visit the aquarium.
- Extension: Essentially furthering this study with more equipment for full water quality break down and turtle health analysis from blood samples and physical examinations. This would be a great study for more concrete conclusions about the current turtles’ health and aquarium suitability.

For the Aquarium
This study has also resulted in recommendations for improvement of the current aquarium.

- Supplies: A scale to determine accurate food along with a calculator. The scale would be used to measure the turtles to keep track of their weight, noting any changes and then using the weight to calculate how much food should be given. Equipment to test the water would be helpful. All of these things cost though and finding support is going to be important to have a successful aquarium.
- Feeding Schedule: Developing a sheet that has to be initialed each day by the completion of feeding the turtles to ensure daily feeding. An example was made and presented in Appendix 4.
- Observation Schedule: Developing a sheet that has to be initialed each day after a short period of observations, noting any abnormal behaviors.
- Further Construction: Finishing excavation of the extension areas and preventing leakage.
- Circulation: Figuring out how to circulate the water in the aquarium, contacting experts.
- Reaching Out: Contacting NGOs for help in completing the aquarium. It has great potential but needs support, so by telling the aquarium’s story others may offer help.
- Planned Release: Having set releases for the turtles, if sick when they have recuperated, reaching a certain weight, or only holding for a year. Having the release be a community activity to show that the healthy sea turtle should be living wild in the ocean.
References

Aliy, A. A. Discussion about Uzi. 2013
Aliy, A. A. Interview about aquarium history. 2013
George, R. Health Problems and Diseases of Sea Turtles in Lutz, P. and Musick, J. The Biology of Sea Turtles. CRC Press. USA. 1996.
Mitchell, E. Sea Turtle Rehabilitation: Research and Education. georgiaseaturtlecenter.org. 2013.
Ripple, J. Sea Turtles. 1996
Appendix 1: Interview

Interviewee: Aliy Abdurahim Aliy

Profession: Wildlife Officer

Date: April 24, 2013 5pm-6pm

How was the aquarium started?
   Initial idea came from Mnarani Aquarium. World Unit gave support starting with a

Were there any necessary permits?
   Followed Menai Bay Conservation guidelines, contacted Director of Fisheries.

Why did you want to start an aquarium?
   To bring conservation to Uzi and help turtles to rehabilitate rather than be eaten.

When are these turtles from?
   Sept-Nov 2012. Second group, the first group was released back into the ocean by a
   specialist and two sick ones were sent to Mnarani.

Who buys/eats turtle meat?
   From an unofficial survey many of all ages and genders in Uzi, lots of fisherman.

Where/who do the turtles come from?
   Fisherman, accidental catch. One from diving in to capture a sleeping hawksbill.

How do they know to bring the turtles to you?
   Knowledge of the aquarium has spread.

Do you explain why you are taking the turtles? What do you say?
   Yes that it is important to conserve sea turtles, that they are supposed to live in harmony
   with us, and that their grandkids may never know sea turtles.

Do you think paying per weight creates a market for them?
   Very careful to not over pay, never experienced purposeful catchment.

Do you have interest in developing an educational program?
   Yes it is in the plan start with fisherman try to go to local schools but they have a
   curriculum in place already.

Where are they being caught?
   All over in gill nets.

Do you have plans to release?
   No because afraid they will be caught again and eaten/killed.

Is there a feeding schedule?
   Yes members of the Society for Uzi Conservation of 20 members and 14 active members.
   All Ages and genders.

Do you think the aquarium needs any equipment for proper turtle care?
Yes but it is about obtaining the resources to get them.

What is conservation to you?

Use everything then nothing will survive. Using resources wisely. Analogy: If you eat all of what you caught in one day and you have no means of further catching you will die the next day. Life without conservation is no life because everything will die out.

Appendix 2: Aquarium suitability and sea turtle health data tables.

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Neap tide</th>
<th>Spring tide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low tide</td>
<td>High tide</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>29.375 ± .25</td>
<td>31 ± .71</td>
</tr>
<tr>
<td>pH</td>
<td>5.833 ± .29</td>
<td>5.25 ± .35</td>
</tr>
<tr>
<td>Salinity (%ppt)</td>
<td>30 ± 0</td>
<td>28.875 ± .18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual Analysis</th>
<th>Neap tide</th>
<th>Spring tide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low tide</td>
<td>High tide</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>Murky/ bottom not visible</td>
<td>Murky/ bottom not visible</td>
</tr>
</tbody>
</table>

Table 1: Water quality measurements of the aquarium were taken for each tide. The two ponds were connected and showed no difference. The different conditions tested were temperature (° C) via thermometer, pH via universal pH paper, salinity via refractometer, and visual observations.

<table>
<thead>
<tr>
<th>Pond</th>
<th>Shade coverage</th>
<th>10am</th>
<th>3pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>1E</td>
<td>50%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>2E</td>
<td>10%</td>
<td>60%</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Shade coverage of each section of the aquarium/pond was observed for a morning and afternoon time. Descriptors were used for each different section within each pond: E refers to extension and C refers to cave.

<table>
<thead>
<tr>
<th>Turtle</th>
<th>Species</th>
<th>Carapace Length (cm)</th>
<th>Carapace Mud coverage</th>
<th>Carapace marks</th>
<th>Flipper Condition</th>
<th>Head condition</th>
<th>Eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Green</td>
<td>62.17</td>
<td>90%</td>
<td>White scrape, 10cm: top right</td>
<td>No abnormalities</td>
<td>Barnacle present, app. 2cm in D</td>
<td>No abnormalities</td>
</tr>
<tr>
<td>B</td>
<td>Green</td>
<td>42.6</td>
<td>40%</td>
<td>White scrapes: outer edges of scales</td>
<td>Small discoloring: back right</td>
<td>No abnormalities</td>
<td>White crud in corners</td>
</tr>
<tr>
<td>C</td>
<td>Green</td>
<td>35</td>
<td>60%</td>
<td>Several small sections missing: center</td>
<td>Small section missing: back left</td>
<td>No abnormalities</td>
<td>White crud in corners</td>
</tr>
<tr>
<td>D/E</td>
<td>Hawks-bill</td>
<td>38.4</td>
<td>95%</td>
<td>Small white circle: bottom right</td>
<td>No abnormalities</td>
<td>No abnormalities</td>
<td>No abnormalities</td>
</tr>
</tbody>
</table>
Table 3: Each turtle was observed for carapace condition, flipper condition, and eye condition. Measurements of Carapace length were taken with a tape measure. The two hawksbill turtles were undistinguishable.

Appendix 3: Pictures of Uzi Aquarium.

Picture 1: Pond 1 and boardwalk
Picture 2: Pond 2 at the start of spring high tide.

Picture 3: Seven pipes for the circulation and entry of water in pond 2.

Picture 4: Murky, oily, silt layer being let in through the pipes.
Picture 5: Carapace view of turtle C. Small areas missing on vertebral scale 4 (Photo Credit Mariah Kuitse).
Appendix 4: Example data sheet schedule.

This schedule could be implemented at the Uzi Aquarium for daily feeding and behavioral regulation of the sea turtles after being translated into Kiswahili. For educational purposes a short description of green and hawksbill diets along with conservation needs are attached. Placement on a plastic board could allow daily writing to be washed off every month.

**Uzi Marine Turtle Aquarium**

Green turtles may be identified by their golden, green shell and are herbivorous animals, meaning that they eat plants. They enjoy eating multitudes of seaweed and seagrass. The Hawksbill turtle may be identified by their black jagged shell and is carnivorous meaning it eats meat. The hawksbill enjoys eating sponges, jellyfish, corals, sea urchins, fish, and molluscs. The turtles should be fed 1-5\% of their body weight daily.

Sea turtle populations are declining due to the heavy exploitation for turtle products. The sea turtle is important because of the roles it plays within the many ecosystems of the ocean. If the sea turtle was so to go extinct this would hurt many seagrass beds, coral reefs, beach shores, and other organisms the sea turtle interacts with. Help conserve the sea turtle!

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Total green weight (weekly)</th>
<th>1-5% of green turtle weight. (kg*.01 to kg*.05)</th>
<th>Total hawksbill weight (weekly)</th>
<th>1-5% of green turtle weight. (kg*.01 to kg*.05)</th>
<th>Amount fed</th>
<th>General Observations</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/04/2013</td>
<td>9:00am</td>
<td>225kg</td>
<td>2.25-11.25kg (225*.0= 2.25; 225*.05=11.25)</td>
<td>100kg</td>
<td>1-5kg (100*.01=1; 100*.05=5)</td>
<td>10kg seaweed 3.5kg sponge</td>
<td>Turtle B ran into coral rag edge hitting its’ head</td>
<td>OC</td>
</tr>
</tbody>
</table>