Monitoring of the Critically Endangered Hawksbill Sea Turtle (Honu ʻea) on Hawaiʻi Island

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Abstract

One of the requirements of the University of Hawai‘i at Hilo Tropical Conservation Biology and Environmental Science graduate program’s professional internship track is the successful completion of a 600-hour internship. My professional internship with the Hawai‘i Island Hawksbill Project started May 12, 2019, and ended August 18, 2019. Hawksbills *(Eretmochelys imbricata)* are a Critically Endangered species worldwide. Monitoring of the female nesting population and protecting their nest from predators is essential to ensuring that this species will continue to thrive. This internship required hiking up to 12 miles long, over rugged lava terrain, while carrying a 30-pound-plus backpack filled with personal and field equipment. The treks were necessary to reach remote beaches for monitoring the nesting behavior of the hawksbill sea turtle. Public outreach is the foremost principle of this project because outreach brings the awareness needed to motivate the island community to join and assist in protecting this vulnerable species.

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Introduction

Background on Species of Interest

The oldest known sea turtle, *Desmatochelys padillai*, has been on Earth for approximately 120 million years. The youngest sea turtles, the olive ridley (*Lepidochelys olivacea)* and Kemp's ridley (*Lepidochelys kempii)*, have presided on Earth for 30 million years (Cadena et al. 2015). Today, there are seven species of turtles that exist, including the hawksbill sea turtle (*Eretmochelys imbricata*, also known as *honu 'ea* in Hawaiian), the green (*Chelonia mydas*, also known as honu), the olive ridley, the Kemp's ridley, the loggerhead (*Caretta caretta)*, the leatherback (*Dermochelys coriacea*), and the flatback (*Natator depressus*). Except for the flatback sea turtle, all six remaining species are found in US waters (Cadena et al. 2015), and the green, hawksbill, leatherback, and loggerhead sea turtles reside in the Hawaiian waters (NOAA & NMS 2020).

Hawksbill sea turtles have a circumtropical distribution and navigate between 30°N and 30°S within the Atlantic, Pacific, and Indian Oceans (NOAA & USFWS 1998, NMFS & USFWS 2018). They are the focal point of global conservation efforts for turtles (Gaos et al. 2010) and have been listed as Endangered on the US Endangered Species Act since June 2, 1970 (NMFS & USFWS 2018). In 2008, hawksbills were listed as Critically Endangered by the International Union for Conservation of Nature (IUCN), as indicated by their <84% population decline since 1990 (Mortimer & Donnelly 2008). The IUCN is a comprehensive information source of global extinction risk status of animal, fungus, and plant species. The IUCN helps guide present conservation, informs future conservation, and prioritizes funding (IUCN 2020).

Exploitation for the tortoiseshell trade is a major historical population threat (Groombridge & Luxmore 1989). Today, the cause of sea turtle population decline globally has

been the unsustainable harvesting of shells (NMFS & USFWS 1998). Due to the high market value of tortoise shell taxidermy, jewelry, and fashion accessories, the hawksbill is the species most at risk of extinction, and it is federally recognized as endangered in the Hawai‘i archipelago (US Fish and Wildlife Service 2020). Universal threats to the hawksbill revolve around urbanization and coastal development to nearshore nesting beaches. Protection of this species can be accomplished by bringing awareness to the areas in which females can lay their eggs. Monitoring egg collection, reducing bycatch within artisan fisheries, and improving the health of coral reefs —a major habitat of hawksbills—are all solutions to curtail these anthropogenetic threats to hawksbills (Jackson 1997; Wulff 2006; Hoegh-Guldberg et al. 2007 as cited by Van Houtan et al. 2012).

Locally, there are six main threats to the sea turtles on Hawai‘i island. These include sea level rise, light pollution, native and non-native predation, marine debris, human vehicular traffic, and foot traffic on beaches. Sea level rise is the result of loss of nesting habitat due to inundation. Light pollution confuses the sea turtles, given their dependence on the natural moon reflexivity on the nearshore waters when entering the ocean. Native and non-native predation can reduce nest success rates. Marine debris can cause entanglement and suffocation, and if ingested can cause indigestion, malnutrition and/or death. Human vehicular traffic can disturb the delicate turtle eggs buried on the beach. Foot traffic on beaches can possibly cause premature nest emergence (Kurpita & Peebles 2018). Diagnosing the potential threats to hawksbills on Hawai‘i island allows for more cohesive management and conservation of the hawksbill sea turtle species.

The hawksbill colony in the Hawaiian Archipelago is the smallest known hawksbill nesting population in the world; however, it is the largest population in the U.S. Pacific Islands

and the Central North Pacific Ocean (Gaos et al. 2020), as well as in the United States (Gaos et al. 2020). Over ninety percent of documented hawksbill nesting sites are found on Hawai‘i island (Kurpita & Peebles 2018). The remaining ten percent occur on Maui and Moloka‘i, and there are 15 known nesting beaches on Hawai‘i island.

In Hawai‘i, the hawksbill nesting season occurs from April to November, and the adult female will lay three to five nests per season—biannually on her natal beach—with each nest containing 130 to 160 eggs (NOAA 2021). Based on the Final Report for 11/01/2015-10/21/2019, the individual 2019 nesting season documented 43 nests alone (Kurpita 2019). The specific nesting behavior is dependent on the individual, and some nesting hawksbill females will come up, dig around the naupaka *(Scaevola taccada)* for about an hour, lay their eggs, and return to the ocean within ninety minutes. Others take much longer and "false nest." This occurs when an adult hawksbill turtle starts to dig around a naupaka grouping but decides that the spot is not appropriate for a nest. She will then proceed to several other locations before eventually picking a site in which to lay her clutch.

After a female has laid her eggs, they will take around sixty days to incubate and hatch (NOAA 2021). Once the hatchlings emerge, they will make their way to the ocean, with only one in one thousand surviving into adulthood (SCDNR - Marine Turtle Conservation Program 2013). It takes 17 to 22 years for a hawksbill to mature into a juvenile, and between its 23rd to 36th year, it develops into an adult sea turtle (NOAA & USFWS 2018). As adults, hawksbills reach sexual maturity and may experience courtship and mate. The fertilized female carries her eggs to the beach in which she was born to start the sea turtle life cycle over again. It is interesting to note that female hawksbills not fertilized by a male turtle, also return to their natal beaches and nest, even though their eggs will be infertile.

Evidence of mitochondrial DNA (MtDNA) suggests that the Hawai‘i hawksbills are a distinct management unit that require significant attention to the threats facing the Hawai‘i island population (Goas et al. 2020). MtDNA is inherited solely from the mother, making it an exceptional comparative measuring unit of the nesting hawksbill female population trends in Hawai‘i and when conducting global comparisons. MtDNA analysis has made it possible for distinguishing the Hawai‘i hawksbill population as a distinct management unit, and has added viability to the mixed-stock analysis with the goal of identifying foraging areas (Goas et al. 2020).

Background on Agency

The Hawai‘i Island Hawksbill Project (HIHP) is the leading organization on Hawai‘i island that actively monitors and protects hawksbill sea turtles. The HIHP was founded by Hawai‘i Volcanoes Natural Resources Management Division following hawksbill documentation in the late 1980s (Kurpita & Peebles 2018). The HIHP is a partnership between the Hawai‘i Volcanoes National Park (HVNP), U.S. Fish and Wildlife Service, National Marine Fisheries Service, the University of Hawai‘i, private landowners, and non-profit organizations (Kurpita & Peebles 2018). The purpose of the HIHP is to help the recovery of the hawksbill species on Hawai‘i island. The overarching goal of the HIHP is to delist the species from the Critically Endangered species list (NMFS & USFWS 1998).

The HIHP identifies hawksbill nesting activity, collects baseline data, manages, and protects nesting habitat, ensures that hatchlings safely reach the ocean, reduces non-native predators and vegetation, and promotes public stewardship of marine ecosystems through educational outreach (Kurpita & Peebles 2018). The HIHP began monitoring hawksbill nesting activity in 1989, and the tagging of nesting hawksbills began in 1991, while intensive monitoring

efforts of nesting beaches both inside and outside of the park commenced in 1993 (Kurpita & Peebles 2018). In 2019, the HIHP directly monitored eight beaches: ʻĀpua, Keauhou, Halapē, Kamehameha, Punaluʻu, Pōhue, Humuhumu, and ʻĀwili, all located on the southern coast of Hawaiʻi island. Additionally, community volunteers monitored two beaches on the northern coast of Hawaiʻi island: Waimanu and Waipiʻo.

As previously mentioned, one of the requirements of the University of Hawaiʻi at Hilo (UH Hilo) Tropical Conservation Biology and Environmental Science (TCBES) graduate program's professional internship track is the successful completion of a 600-hour internship. My professional internship with the HIHP began on May 12, 2019, and ended August 18, 2019, with total volunteer hours equaling over 1,000 hours.

Purpose of the Professional Internship Project

Overarching Purpose

My internship with the HIHP assisted with the collection of hawksbill behavioral data. This data includes: nesting activity and behavior, observed abnormalities, nest translocation, monk seal sighting, nesting success, hatch success rates, carapace measurements, hatchling activity, ocean currents, moon phases, weather, and identifying the sex of mammalian predators. My internship project also assisted with recovering this species by reducing non-native plant vegetation, controlling predators, and promoting public stewardship of marine ecosystems through educational outreach.

Learning Objectives

Graduate Student Learning Objectives

My graduate student learning objectives for my professional internship with the HIHP centered around involvement with an organization that monitors Critically Endangered species behavior and participates in public outreach. Collecting hawksbill nesting activity and nest success rate data at different nesting beaches on Hawai‘i island supported the HIHP's goals in understanding how the species will be monitored and protected for future generations. Other goals included properly citing literature, articulating a well-written literature review for my course assignments, completing a final report for the UH Hilo Master of Science in TCBES, and publishing my report to the HŌKŪ Library. Proficiency in interpreting geospatial data was also a graduate school goal.

Professional Development Objectives

My professional development objectives included participating in meaningful and challenging work, obtaining a mentor experience, expressing knowledge of an agency ecosystem, developing an understanding of policy and regulations, and effectively communicating my internship experience to a broader audience. Beyond these, I wanted to understand the process of grant writing, to learn how 501©3's are funded, and be exposed to the management techniques for the hawksbill on Hawai ʻi island.

Professional Internship

Role

As a Volunteer in the Park (VIP), my role with the project was to collect baseline data on adult female hawksbill nesting activity, protect nests to ensure that hatchlings safely reached the

ocean, and to collect data on nest success on Hawai‘i island. Additionally, I conducted educational outreach at two elementary schools.

Responsibilities

As a VIP, my primary responsibility was to collect as much data about the nesting Hawai‘i Hawksbill population on Hawai‘i island as possible, while upholding proper safety guidelines during preparation for, transportation to, and entering the field. Monitoring for Critically Endangered species activity took place under the guidance of project staff adhering to project protocols under U.S. Fish & Wildlife Threatened and Endangered Species permit TE-739923-8. Having the proper equipment and assigned tasks helped with the overall flow of the agency ecosystem and workflow.

All volunteers were responsible for their own field equipment and food rations packed for a specified number of nights. These items were expected to be ready the night before. The necessary items for the job included the EA-1 and backcountry keys, volunteer NPS t-shirt, daypack, proper hydration, personal field notebook, headlamp, watch, pocketknife, first aid kit, spare headlamp, batteries, hiking boots, closed-toed sandals, dark clothing, hammock—especially for ‘Āpua—, and personal items such as sunscreen, a hat, and medication.

It was the sea turtle monitoring team’s responsibility to conduct a vehicle check before going into the field. During a vehicle check we would make sure there was a full tank of gas, an adequate amount of oil, that the breaks and signaling lights were working correctly, and that all seatbelts were fastened.

Maintaining well-coordinated lines of communication and tasks of volunteers coming in and out of the field allowed a steady flow of information to be brought to the attention of the monitoring staff. Field notes were used to record previous days/nights’ monitoring activity in

the “turtle office,” (see Figure 1) so that the volunteers understood what was going on at a specific nesting site and what they were expected to accomplish during their monitoring assignment. Per agency protocol, field phones were checked by each monitoring team and supplied with fully charged and extra batteries.

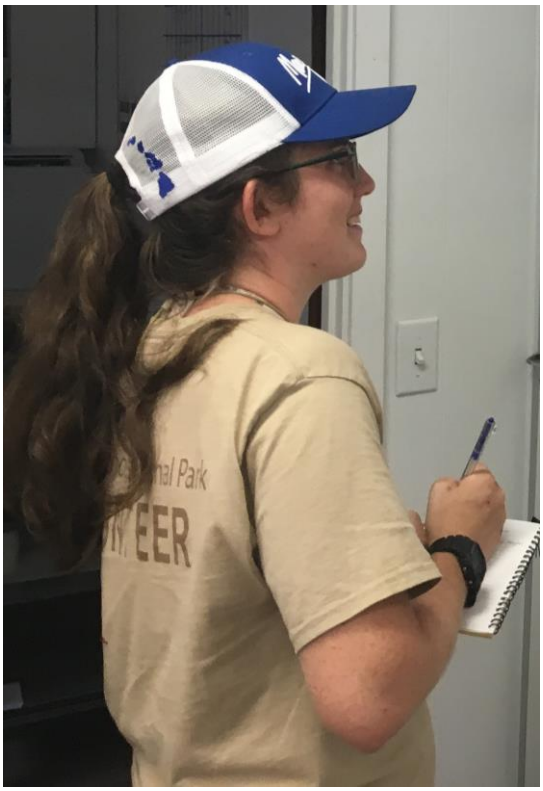


Figure 1. Kelsey Recording Previous Hawksbill activity in the “Turtle Office”.

Expectations of a Professional Internship Project

Meaningful and Challenging Work

Skills gained during my internship include assessing a lava terrain landscape, using a Passive Integrated Transporter (PIT) tag scanner, certification in defensive driving, four-wheel drive experience, sea turtle tagging, installing nest cages, completing field data sheets, conducting non-native predator control, excavating nests, monitoring sea turtle nesting activities, and participating in public outreach. The most meaningful accomplishment of my internship with HIHP consisted of tagging a new nesting female on 07/07/2019 at 00:35. This was especially important because it continued the project's 1992 legacy of tagging nesting hawksbills for population assessments. This new sea turtle could very well be a returning female from the original clutch from when the project first started, knowing that hawksbills take 20-29 years to sexually mature (Gibbons T. 2020). Collecting data for the female nesting population, hatchling success rate, and non-native predator prevention were meaningful to the projects goals of monitoring and protecting this species.

Knowledge of the Agency's Ecosystem

The HIHP staff includes a full-time University of Hawai'i-Pacific Cooperative Studies Unit (UH-PCSU) project coordinator, a UH-PCSU field technician, 51 full-time NPS VIPs (Volunteer's in Park), and 28 part-time resident VIPs. Full-time NPS VIPs individually contributed three to four months of their time to the project. Private property owners play a large part in this ecosystem because they allow members of the HIHP onto their property to conduct hawksbill monitoring efforts. The project manager and the field technician are employed through The Research Corporation of the University of Hawai'i (RCUH), and funding support for the project is provided by the National Marine Fisheries Service (NMFS), Pacific Island

Regional Office (PIRO), the Hawai‘i Pacific Parks Association (HPPA), the National Park Service (NPS), and the World Turtle Trust (WTT) . A sub-grant-funded by the Pacific Cooperative Studies Unit at RCUH endorses activities at HVNP.

The World Turtle Trust collaborates with sea turtle conservation projects around the world and selects sea turtle conservation projects based on an organization's commitment and determination to create change and have a significant impact on saving sea turtles (World Turtle Trust 2020). The Pacific Island Regional Office works with the Pacific Island Fisheries Science Center to integrate new scientific techniques into policy and management, and decision-making is influenced through working together to conserve and manage domestic and international marine resources (Pacific Island Regional Office 2015).

Parameters of the Agency's Purview

The long-term goals of this project are to strengthen hawksbill population assessments through robust record-keeping of their nesting activity, evaluation of genetic diversity, and identification of stock structure. Additional objectives include understanding hawksbill movement, identifying marine habitat use of hawksbills, calculating the age to neritic recruitment, classifying first reproduction, assessing juvenile and male hawksbill population sizes, recognizing diet-requirements, monitoring habitat needs of hawksbills, measuring temperature parameters, and plotting the potential impacts of climate change (NOAA & USFWS 2018). Discerning the number of nesting females and their nesting habitats facilitates understanding the state of populations in the main Hawaiian Islands.

One way of accomplishing population assessments is through full-time monitoring and conservation efforts at nesting beaches on Hawai‘i island. These fifteen beaches are included in the monitoring effort: Āpua, Keauhou, Halapē, Kamehame, Punalu‘u, Kōloa, Nīnole,

Kahakahakea, Haliʻipalala, Puʻu Kī, Pōhue, Humuhumu, ʻĀwili, Waimanu, and Waipiʻo. Effective observance of nesting females is accomplished using flipper and PIT tags to ensure ongoing identification. Collection of tissue samples from nesting females is conducted for stock structure analysis (NMFS & USFWS 2018).

The long-term goal of increasing hawksbill overall population size can be accomplished by decreasing nesting beach impacts, maximizing hatchling production, and protecting nesting females at nesting beaches. Ongoing project disciplinary actions include understanding why hawksbills on Hawaiʻi island are not increasing, pursuing stable funding for nesting beach monitoring, and accumulating financial resources for in-water monitoring projects. Promoting public awareness and educational outreach to island communities about the hawksbill presence, status of the Hawaiian hawksbill population, their cultural significance, and actions the public can take to promote information gathering help increase the overall conservation and recovery of this species. Compiling and revisiting literature regarding Hawaiʻi hawksbills help in facilitating analysis and publication of existing data from all monitoring projects. Continuation of inter/intra-agency coordination and partnering with NGOs help in getting the hawksbill population figures to those who can impact the population in a positive way. The responsibility of HIHP is only Hawaiʻi island—HIHP operations are not international, except for attendance of international sea turtle conventions.

Advocacy or Outreach Experience

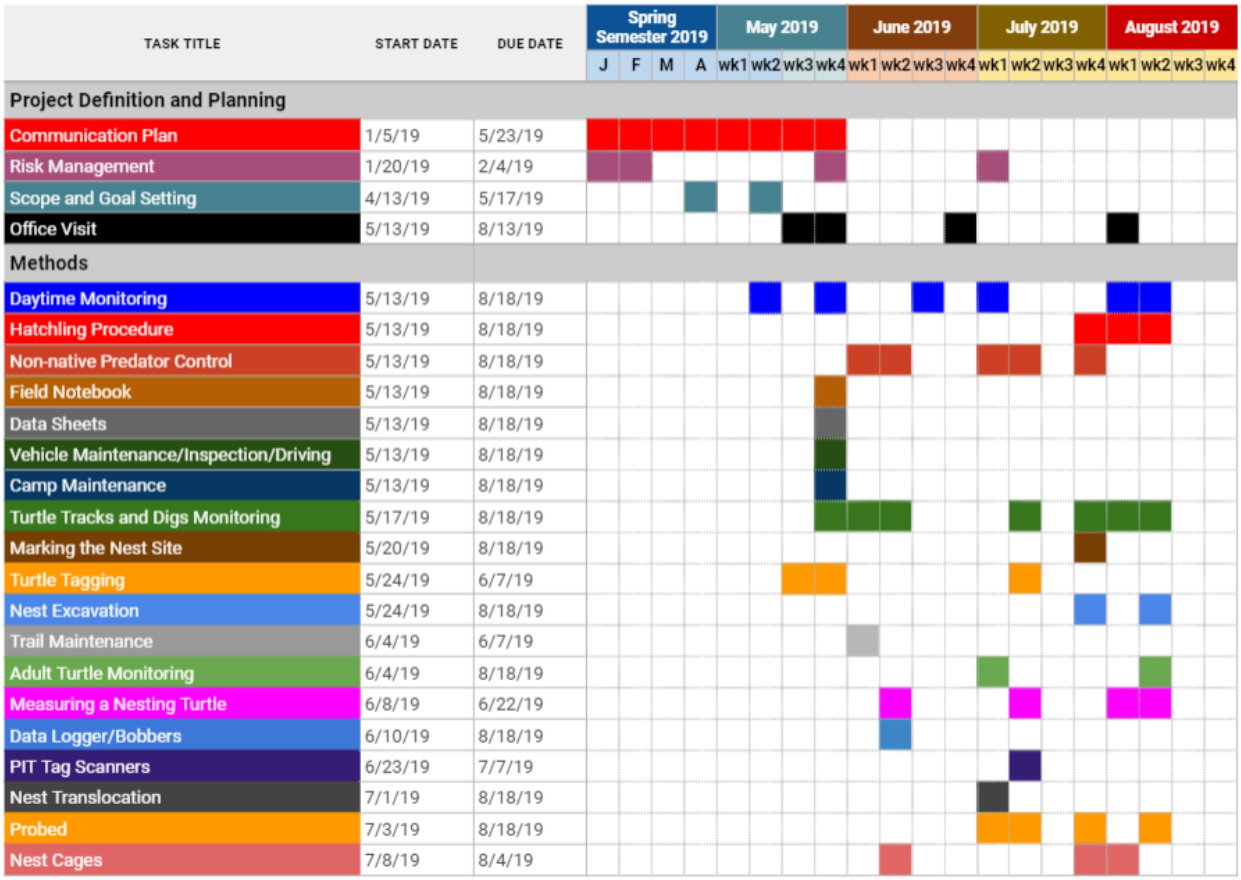
During my internship experience, I participated in both an outreach activity and a hands-on learning activity at two elementary schools on Hawaiʻi island. At The Volcano School of Arts & Sciences, I taught first grade students about the hawksbill lifecycle stages and threats on Hawaiʻi island. The lesson plan followed the Next Generation Science Standards and involved three

different ways of learning: aural, visual, and kinesthetic. The second experience I participated in while doing my internship was an outreach event at Na‘alehu Elementary school. There, I introduced elementary school children to the work of the HIHP by detailing our monitoring efforts at different nesting beaches on Hawai‘i Island, showing students hawksbill specimens, describing a model of a hawksbill hatchling, and showing the students hatched hawksbill egg shells.

Timeline

My internship process began with the UH Hilo TCBES internship coordinator, the HIHP project manager, and myself, discussing the internship possibilities in January of 2019. The internship formally began May 12, 2019, and ended approximately 1,000 hours later on August 18, 2019 (Table 1).

Table 1. Timeline of 2019 Internship with The Hawai‘i Island Hawksbill Project.



Approach

Major Undertaking #1: Tagging a Sea Turtle

Strategies and Methods

The strategies for tagging a sea turtle before going out into the field include reviewing the Hawai‘i Island Hawksbill Project Orientation Handbook, and practicing tagging with metal flipper tags using pliers on a piece of cardboard. This task is accomplished with one volunteer reading from the turtle handbook, and another acting out tagging a sea turtle.

The tools necessary to tag a hawksbill while in the field include : a headlamp with a red light, a turtle towel (to cover the turtles' head), metal flipper tags, tagging pliers, four sides of a turtle box, a field notebook, and a pen. When applying a tag to a live turtle, volunteers must first work together to restrain the turtle, and check for existing tags. If tags are present, that will allow them to identify the sea turtle, if tags are not present, then they will need to remove a tag from the strip of tags and apply that tag into two of the turtles' front flippers using tagging pliers, insuring 1/3 of the tag overhangs the length of the flipper. Volunteers would wear dark clothing and use a red headlamp , whereby reducing disturbance to the nesting female. Working in the dark proved to be challenging, especially when trying to tag the nesting female sea turtle for the purpose of adding her to the population records. Persistent sea turtle monitoring and identification of a returning adult female hawksbill was primarily important to addressing population trends and returnees.

Assessment Method to Evaluate Achievement

Elements that worked well: Working as a team to tag a hawksbill.

Elements that can be improved: No need for improvement identifiable by me.

Major Undertaking #2: Adult Sea Turtle Monitoring

Strategies and Methods

Monitoring adult sea turtles takes an abundance of patience, self-motivation, and diligence. As a sea turtle monitor, waking up every hour of the night is not something that our bodies were meant to do, but for the sake of protecting a Critically Endangered species, it is worth it. Adult sea turtle monitoring is important to the project's objective of "identifying hawksbill sea turtle nesting activity and collecting baseline data" and it included noticing and recording when tracks were observed, when a sea turtle was heard digging, when the sea turtle starts laying (her nest), when the sea turtle started covering, when the sea turtle stops covering, and the estimated time at which the sea turtle returned to the ocean (Kurpita & Peebles 2018). From this undertaking I learned the importance of good communication with team members, so that we were aware of what hours (or shifts) were for sleep, and which shifts took us to do a beach walk. Our beach walks took place from 5:00 p.m. to 6:00 a.m., and during them we would carry the turtle backpack which had everything we needed to tag a sea turtle, measure a sea turtle, and mark a nest. We would also bring a caliper to take the straight carapace length of a sea turtle when it came up on the beach. While monitoring a hawksbill, I realized that they are not always easy to spot since they can hide in the naupaka. It was unusual to see a sea turtle on the beach during the daylight hours. Per protocol, it was the volunteer's responsibly to photograph the adult female turtle during the daylight hours, and to notify the project manager of this occurrence (see Figures 2 and 3).

Figure 2. Adult female Hawksbill. Photo Credit: Abigail Pitney.

Figure 3. Adult female Hawksbill. Photo Credit: Abigail Pitney.

Assessment Method to Evaluate Achievement

Elements that worked well: Working with a partner while preforming beach checks and taking turns to sleep was effective during hourly night beach walks. If a sea turtle arrived, it was the responsibility of the volunteer who saw the sea turtle to wake the sleeping volunteer(s) so he or she could assist with properly restraining the sea turtle, since two (or three) minds are better than one. Using all one's senses is important, as is sticking to using a red headlamp and wearing dark clothing, since these actions decrease the monitoring team's presence on the beach.

Elements that can be improved: As it relates to adult hawksbill monitoring, the methodology for one person to be the "lead" while two (or three) volunteers are in the field would work best for overall workflow. The lead's role would be to inform the other volunteers when to remain quiet and still, when to sneak up on the sea turtle, when the appropriate moment is to input the data logger, and when

to record times of sea turtle behavior. These tasks include restraining, tagging, and releasing the sea turtle back into the ocean. A continued improvement for this project would be an increased number of trained volunteers in order to maintain complete coverage across Hawai‘i island. Identification of the number of nesting female sea turtles via population size estimates may be more holistically improved when proper documentation of the nesting female population and their locations is recorded (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998). Population size estimates are central to understanding the current state of their population across the main Hawaiian Islands (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1998).

Major Undertaking #3: Marking the Nest Site

Strategies and Methods

Color-coordinated markings of the nest site indicated at a glance whether the nest was possible, observed, or finished. Pink ribbon was used to mark the nest as possible if a volunteer assumed evidence of a nest but was unsure if it was in fact a nest. Similarly, if a nest was observed being laid, it was marked with orange flagging, and blue flagging was used to indicate that the nest had been excavated and the egg success rate captured. Fishing bobbers were deployed on the top of the egg chamber (see Figure 4) when the sea turtle was finished laying her eggs but had not started covering them yet. The nest number, observer's initials, and date were written on two bobbers, and the date specifically was recorded on the underground bobber. The nest number, observers' initials, and sea turtle ID number were written on the above ground metal tag attached by a string to an underground bobber. On the colored ribbon, the nest number, observers'

initials, and turtle ID number are recorded, and tied to a piece of coral, a nest cage, or a naupaka branch. Marking the nest site not only identifies the location of the egg chamber, it can also discourage nesting turtles from attempting to dig in the same spot, or on top of another females' nest. Marking the nest makes it easier for volunteers to spot a nest, and clearly identifies the excavated nests.

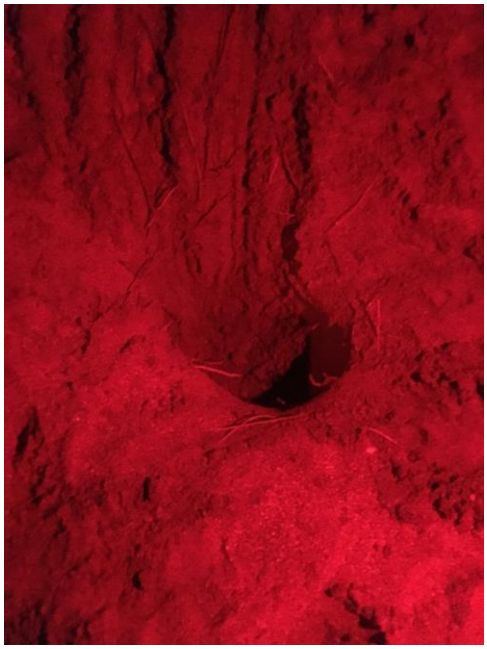


Figure 4. Hawksbill nest, egg chamber. Photo Credit: Kelsey Meagher.

Assessment Method to Evaluate Achievement

Elements that worked well: The noteworthy elements of this undertaking were using the underground bobber with team members' initials written on it, securing a string to the bobber on one end, with a metal tag on the other end of the string and sticking out of the sand. This made it easy to identify the sea turtle, the nest

number, and the volunteers who observed the sea turtle laying. The colored flagging tape worked well in identifying the status of a nest, as did the recording of who found, observed, or excavated each nest. Marking the nest alerts the public to the presence of hawksbill nests on the beach and smoothing over the previous hawksbill activity ensured no repeats of recorded activity from another volunteer.

Elements that can be improved: No need for improvement identifiable by me.

Major Undertaking #4: Measuring a Nesting Sea Turtle

Strategies and Methods

The strategies for measuring the carapace of a nesting sea turtle involve two methods of measurement: a straight measure using a caliper and a curved measurement using a tape measure. The straight carapace length (SCL) along with the straight carapace width (SCW) measurements are taken with calipers. The curved carapace length (CCL) and curved carapace width (CCW) are taken with a tape measure. The notch-to-tip carapace technique is used for measuring the carapace length, from the center of the nuchal notch (the anterior notch located directly below the sea turtle's head) to the posterior tip of the carapace (Kurpita & Peebles 2018). For measuring the width, the distance across the widest part of the sea turtle's carapace, is measured using a caliper (Kurpita & Peebles 2018). Hawksbills can reach up to three feet in length. I was amazed at how large these reptiles become, and the timidity of this species.

Assessment Method to Evaluate Achievement

Elements that worked well: Working as a team to restrain the sea turtle, and effectively communicating the sea turtle carapace measurements.

Elements that can be improved: The elements that could be improved would be having a seasoned designated leader for the measuring process and practicing on a sea turtle shell before going out into the field.

Major Undertaking #5: Nest Cages

Strategies and Methods

The purpose of installing a nest cage is to protect the nest from predation, vehicular traffic, and human disturbance; it also helps volunteers out in the field know where a sea turtle has laid her eggs. During my internship with the HIHP, I learned how to build, install, and mark nest cages, and found that working together to build the enclosure made it easier than building it alone (see Figure 5). Tools and materials required to build a nest cage include fencing material, chicken wire, needle nose pliers, wire cutters, stainless steel straight gauge wire, and a "Hawksbill, Do Not Disturb" sign. Per U.S. Fish & Wildlife T&E permit, openings were cut along the base of the nest cages after 45 days of incubation (Kurpita 2019).

Assessment Method to Evaluate Achievement

Elements that worked well: The nest cage itself is a well-thought-out procedure for protecting the egg chamber.

Elements that can be improved: No need for improvement identifiable by me.

Figure 5. Kelsey building a nest cage. Photo Credit: Abigail Pitney.

Major Undertaking #6: Hatchling Procedures

Strategies and Methods

On our nightly beach walks, we are looking for signs of hatchling activity. For example, we might find a few sets of hatchling tracks (see Figure 6) when we come up on a beach. If we find a live hatchling on the beach, then we will ensure that it safely gets to the ocean. Keeping record of when we found hatchling(s) and when they entered the water was enforced. Throughout this process, I learned that hatchlings emerge approximately 55-70 days after their eggs are laid

(Kurpita & Peebles 2018), depending on where the nest is located (sunny or shaded). During my internship, I discovered an unknown nest when a volunteer witnessed two hatchlings on the beach that had emerged from a large naupaka clump. We followed the hatchling tracks back to their origin and discovered the egg chamber buried in naupaka. We prepared a runway (see Figure 7) for the hatchlings that were emerging so they could safely reach the ocean. Hatchlings imprint on their natal beach, which impacts their adult behavior by influencing them to return to the beach on which they were laid (Kurpita & Peebles 2018). During the hatchlings' emergence, we allowed them to find their own way to the ocean so they could imprint on their natal beaches, but we would have assisted them if they were trapped in the naupaka.

Figure 6. Hawksbill hatchling tracks. Photo Credit: Abigail Pitney.

Figure 7. Hawksbill hatchling runway with parallel lines (to see tracks clearer).
Photo Credit: Kelsey Meagher.

Assessment Method to Evaluate Achievement

Elements that worked well: Assisting hatchlings to the beach during the daytime helped protect those emerged hatchlings because increased beach temperatures and exposure to sunlight could cause the hatchlings to perish in the heat. Sitting next to the nest during its hatch window is effective for getting full coverage of hatchling activity.

Elements that can be improved: Making it a point to check under naupaka regularly to see if a live hatchling is present is crucial to hatchling survival, especially at ʻĀpua beach because there is a significant amount of naupaka on this beach.

Major Undertaking #7: Nest Excavations

Strategies and Methods

Nests were excavated 24 hours after an emergence, with the approval of a project manager. The first strategy for accomplishing a nest excavation is for a volunteer, working alongside a project manager, to gently comb the nest with a cupped hand (see Figure 8). This is done so no harm is inflicted on a hatchling that is stuck in the sand. Once the team gets to the egg chamber, the pipped—or pierced turtle hatchling—, the partially developed, the underdeveloped, and the live hatchlings are accounted for (see Figure 9). With these units the monitoring team can then properly calculate the nest success rate. We excavated the nests so that we could identify the hatch success rates of each one during their respective hatch windows. After the excavation, the specimens (sea turtle embryos) were collected and shipped to the NMFS Pacific Islands Fisheries Science Center for DNA analysis (Kurpita 2019).

Figure 8. Kelsey, Lauren and UH Hilo student preforming a nest excavation near an observed nest.
Photo Credit: UH Hilo Student.

Figure 9. Hawksbill eggs and eggshells. Photo Credit: Kelsey Meagher.

Assessment Method to Evaluate Achievement

Elements that worked well: Brushing the top of the sand gently, being mindful of rocks and roots, dividing and accurately communicating the pipped, underdeveloped, and partially developed sea turtle embryos in separate piles assisted in accurately calculating the nest success rate. Recording the initials of the volunteers who excavated the nest, the sea turtle ID, and the nest number on flagging was necessary for backlogging hawksbill nesting data, and for identifying the locations of the sea turtle nests.

Elements that can be improved: Having a second volunteer calculate the nest success number, thereby reducing possible mistakes.

Major Undertaking #8: Non-native Predator Control

Strategies and Methods

Non-native predator control is conducted to reduce the potential negative impacts of predators at nesting beaches. Predators such as mongooses and feral cats can dig, eat, and destroy sea turtle nests, so the act of making and installing a nest cage is important to increase the hatchling's survival rates. Euthanasia of predators after trapping reduces their populations in sea turtle nesting beach locations. I participated in setting up the Doc250 traps with bait, checking the traps nightly and, when a mongoose was present, performing euthanasia by placing the encaged mongoose in a black plastic bag and slowly adding carbon dioxide (CO2) to the bag using a hose. Once the mongoose was deceased and sexed, it was buried, and lava rocks were set on top so that volunteers wouldn't dig it up by accident.

Assessment Method to Evaluate Achievement

Elements that worked well: Wearing personal protective equipment.

Elements that can be improved: No need for improvement identifiable by me.

Major Undertaking #9: Field Notebooks

Strategies and Methods

Field notebooks are vital to carrying out the long-term goals of this project. There are two field notebooks that are used by volunteers for record keeping of turtle activity: one is kept at each of the nesting beaches for communal use, and a second field notebook is issued to each volunteer so that turtle activity can be captured in its entirety (see Figure 10). Without accurate reporting of what happens while in the field, there would be no tangible way of knowing whether the efforts put forth to protect the hawksbill are working or not.

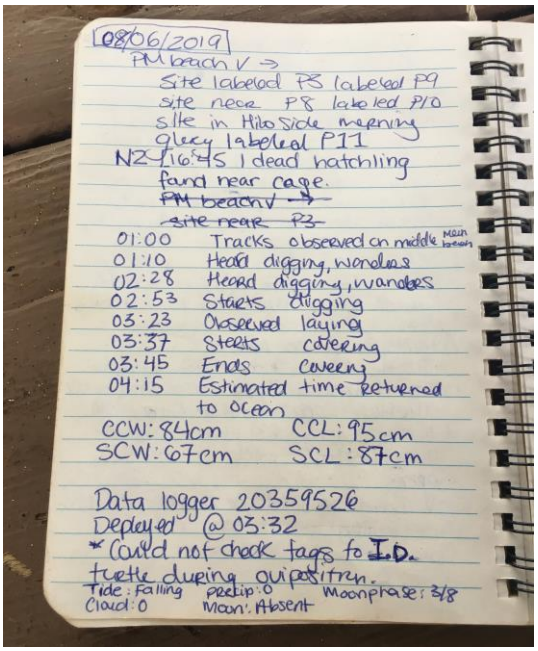


Figure 10. Field notes book recordings of hawksbill activity. Photo Credit: Kelsey Meagher.

At the beginning of a volunteer shift, members of the sea turtle monitoring team would bring their notebooks to the office before each monitoring session to record previous sea turtle activity. A large dry-erase board in the Turtle Office located at Hawai‘i Volcanoes National Park would list each sea turtle being monitored, and at which beach, the dates, and times the sea turtle activity. Volunteers would copy the following data from the board into their individual field notebooks thereby informing previous field crew of recent hawksbill activity: predator traps that were set, nest cages that were installed or that need to be installed, nesting activity, and any information that was brought to the attention of the project manager. On the left-hand side of the white board, volunteers could find out which vehicles were already in the field and which vehicles were available. Likewise, volunteers could be informed which field phones were taken out and which field phones could be utilized (Kurpita & Peebles 2018).

On each of the nesting beach locations, “Rite in the Rain” field notebooks were included in the field backpacks, and within the individual volunteers’ backpack. The sea turtle activity would be recorded there for redundancy and so that the next monitoring team could read the previous team’s work. Updated in real-time, entries would be finalized before leaving the field (Kurpita & Peebles 2018). While working with the HIHP it was important to write legibly using the correct format. I learned that it was easier and more accurate to sit down with the other sea turtle volunteers to discuss what we had just accomplished in the field before completing our notebook entries.

The strategies for taking field notes involve recording daily entries of the date and day of the week, the initials of everyone in the field group, the sea turtle activity that took place in the AM & PM, the AM & PM trap check activity, and the day hikes to adjacent sea turtle monitoring beaches. (Kurpita & Peebles). Measurements of the sea turtles are also recorded in the field

notebook, and these include the sea turtle's CCW, SCW, CCL, and SCL. The data logger number, data logger deployment time, time turtle tracks were first observed, when the sea turtle started digging, when the sea turtle started laying, when the sea turtle starts covering, when the sea turtle stops covering, time of sea turtle restraint, when the sea turtle returns to the ocean, and the sea turtle tag numbers were also recorded. When conducting a nest excavation, the top, bottom, and width of the egg chamber was recorded in centimeters. The number of live sea turtle hatchlings, dead sea turtle hatchlings, partially developed sea turtle embryos, pipped eggs, successful hatches, and nest success percentages were all recorded in the field notebooks. Ensuring the accuracy of the field notebooks brought with it a feeling of importance, a personal responsibility to carry out the project's overarching goal of conducting ongoing monitoring, and informed conservation efforts at known hawksbill nesting beaches.

Assessment Method to Evaluate Achievement

Elements that worked well: Identifying dates and times of sea turtle activity, recording the volunteer's initials, keeping track of nest excavations, calculating nest success rates, and tracking hawksbill activity beach locations.

Elements that can be improved: Having experienced project personnel making the calls when to step in on each procedure.

Major Undertaking #10: Field Data Sheets

Strategies and Methods

In addition to the field notebooks, volunteers would complete the appropriate field data collection sheets. There were nine different field data collection sheets: Data Cover Sheets, Adult Hawksbill Sheets, Field Data Sheets, Hatchling Field Data Sheets, Hatchling Observation Sheets, Next Excavation Data Sheets, Next Translation Data Sheets, Abnormalities Data Sheets,

and Monk Seal Data Sheets. The two data sheets that I used most frequently were the Hawksbill Turtle Data Cover Sheet and the Adult Hawksbill Field Data Sheet.

The Hawksbill Turtle Data Cover Sheet indicated if the trips were camping or day trips, the date, location, observer's names, indication of sea turtle activity or absence thereof, and if traps were set. The type and sex of predator captured are indicated on the cover sheet. Other observations include the summary of sea turtle activity, the number of campers, the number of day hikers, bat sighting, monk seal sighting, and any other human activity on the beach, such as the presence of other campers or fisherman.

The Adult Hawksbill Field Data Sheet was completed for each adult hawksbill that came onto the beach, including any false nesters. This data sheet had the same basic identifiers as the field notebooks, such as the date, location, indication of camping or day trip, and observer's initials. Beyond that, detailed information of the sea turtle activity was recorded via circling the following activities that were observed: sea turtle nested, sea turtle false-nested, new sea turtle tagged, known sea turtle tagged/re-tagged, sea turtle observed (no nesting attempts), sea turtle that damaged existing nest, nest number, number of nests damaged, successful nest probe, and did not probe. The nesting sea turtle information included when the sea turtle was first observed; when she starts digging, laying, covering, and stops covering her nest; when she was restrained, when she returned to the ocean, and whether a data logger was deployed. This form also documented the number of hatchlings assisted to the ocean.

Additionally, the Adult Hawksbill Field Data Sheet captured the environmental conditions at the time of the sea turtle's arrival on the beach. A tide chart was used to identify whether the tide was low, falling, high or rising. Other factors recorded included the phases of the moon, the presence or absence of the moon, observable cloud cover, and the degree of

rainfall. Individual hawksbill identifiers, such as carapace measurements, flipper tags, PIT tags, sea turtle ID number, and abnormalities were also noted.

Assessment Method to Evaluate Achievement

Elements that worked well: Recording the hawksbill sea turtle behavior, the environmental conditions, nesting patterns, sea turtle measurements, and sea turtle flipper tag identification was advantageous for project management. These recorded factors enhanced insight into hawksbill nesting behavior, as well as their personal characteristics and their nesting locations.

Elements that can be improved: Make sure that each volunteer knows the time in which to approach the sea turtle.

Outcomes

Deliverables

During the Fall 2019 Semester of my graduate studies, I attended "Teaching Science in Hawai‘i Island schools," an education class offered by UH Hilo's School of Education. A major component of the class was to create and implement a lesson plan using Next Generation Science Standards (NGSS 2013). The grade levels for this lesson plan were kindergarten through third grade, and the NGSS sought "to develop models to describe that organism have unique and diverse life cycles, but all have in common birth, growth, reproduction, and death" (NGSS 2013).

The *Life Cycle of a Sea Turtle and its Environment* lesson plan challenged students to properly identify the sea turtles' physical characteristics, their structures, their functions, and their life cycle. During this lesson, students also experienced a physical component. The Physical Education component of this lesson plan had students play the outdoor game "Turtle Hurdles," adapted from Colby McNaughton's "Turtle Hurdles" game. The Physical Education

component was a predator and prey game, where some students acted as sea turtle hatchlings (the prey), while the other students acted as potential threats to the sea turtle hatchlings such as: crabs, mongooses, cats, rats, sharks, and marine debris.

Before going out and playing the game, students first identified the structures, explained the functions of a sea turtle, identified the four stages of the sea turtle life cycle, and brainstormed the potential threats to sea turtles throughout their lives.

Students showed evidence of learning by properly completing a diagram of the hawksbill anatomy, responding to critical thinking questions about the book "The Adventures of Gary and Harry: A Tale of Two Turtles," labeling a model of the sea turtle life cycle stages, identifying potential threats to sea turtles, and finally participating in the "Turtle Hurdles" game, where students demonstrated their knowledge of the four phases of the life cycle (Matsumoto L. 2006).

The beginning of the lesson plan starts out with first reading "The Adventures of Gary and Harry: A Tale of Two Turtles" aloud to the students. During the reading, the following questions are asked of the students: "How are we going to keep plastics out of the ocean? What is the main threat to the sea turtles Gary and Harry? How did the Marine Debris get there? What happened to the sea turtles? What can WE do to help the sea turtles?" These questions were meant to introduce students to engaging in real-world environmental problems (see Figure 11).

Figure 11. Kelsey teaching first grade lesson plan at The Volcano School of Arts & Sciences, with fellow TCBES Student, Maya Goodoni. Photo Credit: Erica Jensen.

The second part of the lesson plan was to describe the hawksbill structures and functions. The sea turtle head shape helps distinguish the species, a hawksbill has a more pointed beak, and a green sea turtle has a more rounded beak. Hawksbills have overlapping scutes—a thickened bony plate on a turtle's shell—, whereas a green sea turtle has a smoother carapace. Hawksbills have four flippers with an asymmetrical gait, which means that they move their left flipper forward and then their right. In comparison to the hawksbill, green sea turtles have a synchronized gait, meaning that they move both their left and right flippers forward at the same

time. A game of Hokey-pokey was used to teach students how parts of a sea turtle have a similar motion to that of our human anatomy. The structures of the sea turtle included the beak, the claw, the carapace (or shell), the front flippers, the scutes, the plastron, and the rear flippers. For our human anatomy, our mouth (or hand in front of mouth) was used for a beak, a finger for a claw, our back for the carapace, our arms for our front flippers, our abdomen for our plastron, and finally our legs represented rear flippers.

The functions of the sea turtle parts were written down on a white board and described. For instance, the beak is used for tearing, scraping, crushing, or biting. The claw is used for holding onto the female during mating, the carapace is the sea turtle's backbone, and the plastron protects the softer inner parts of the sea turtle, while the scutes protect the sea turtle and assist humans in identifying the different kinds of sea turtle. The rear flippers steer the sea turtle, are used to dig the nest to lay eggs, and to scavenge for food.

Once the students understood the different parts of the sea turtle and how they correspond to our human anatomy, we were then able to play hokey pokey, where we would "put our claw in, put our claw out, put our claw in, and shake it all about!"

The third part of the lesson plan was watching a TED-ED video titled "The Survival of a Sea Turtle" (TED-Ed. 2012). For this activity students were asked to draw each step in the sea turtle life cycle within the appropriate boxes and, in between each life cycle stage, students would write down or draw the different threats that sea turtles face during their life journey. The video was stopped at times to allow the students to draw the different life cycle phases (see Figure 12). After the video was played, a review of what the students wrote or drew for their answers was conducted.

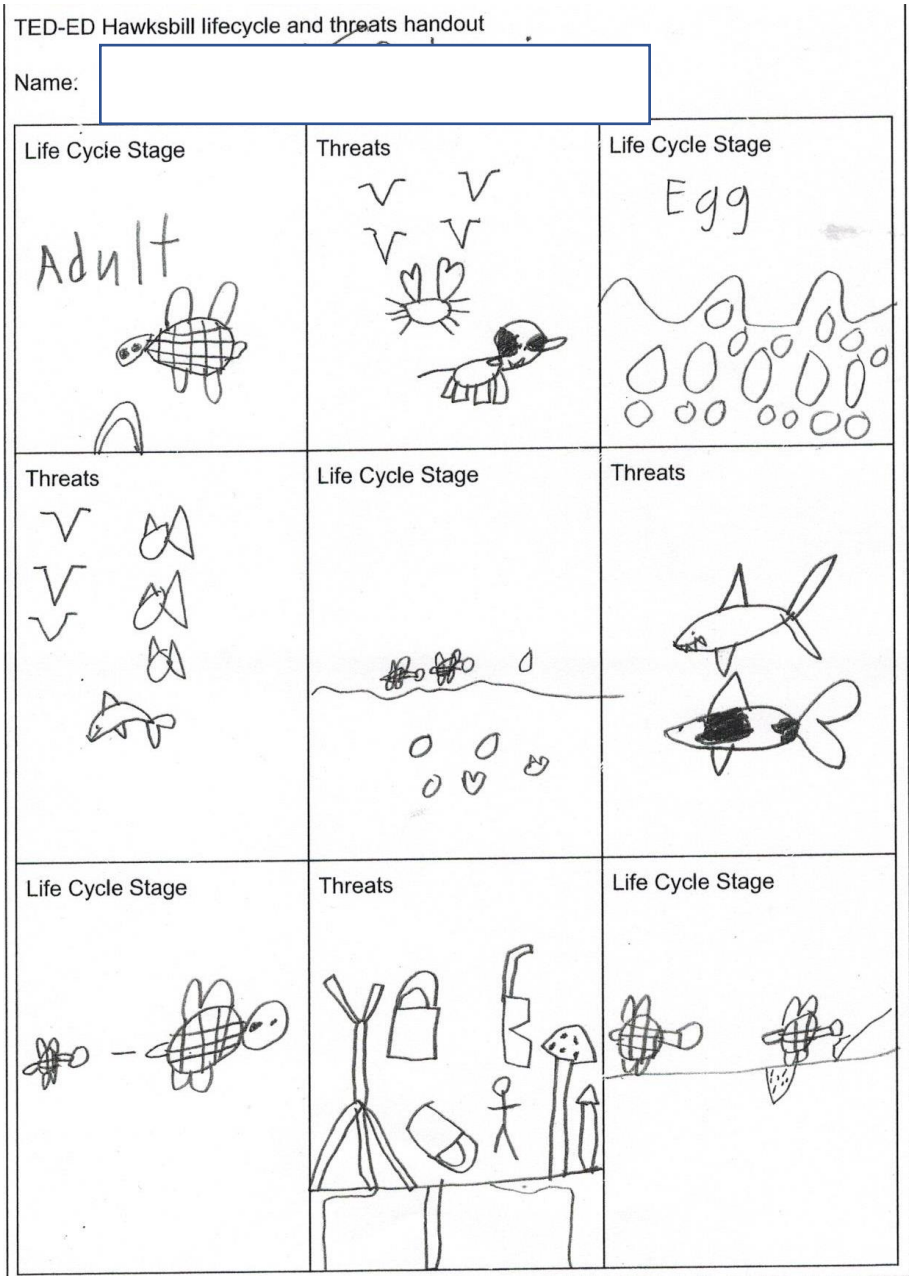


Figure 12. Example of Student work. Photo Credit: Kelsey Meagher.

The fourth part of the lesson plan was to play the outdoor game "Turtle Hurdles." The objective of this game was to learn about conservation issues and predators that threaten sea turtle survival. Students used their thinking skills to add to their na honu (sea turtle) knowledge. The materials used for this game were origami that I made by hand, so the students had a random chance of picking predators or prey out of a cloth bag. The predator and prey animals involved were cats, mongooses, sharks, mice, crabs, and sea turtles. I also threw in a plastic bag so that students would know that marine debris is a potential threat to sea turtles. Ropes were laid down on the ground to mark the beach line, the ocean line, and deep ocean trenches. Ropes were also laid down into oval shapes for sea turtle "safe zones," where predators could not tag/eat them.

Life cycle patterns were emphasized during the game. Before I met with the students in the classroom, I set up the ropes and cones, explained the rules in the classroom, and then recapped the rules while out on the field. Students held onto their origami while playing the game, so that their characters could be distinguished by the other students. While still in the classroom, I drew out the field, and the different locations that the predators would be located—for example, crabs were on the beach, and sharks were in the deep ocean. The goal of this game was for the sea turtles to: emerge from their egg, get across the beach as a hatchling (baby sea turtle), get to the teenage (juvenile) zone, get to the adult zone, and make it back to the beach to lay more eggs. The stages of a sea turtle emphasized in this game included: an egg, a hatchling, a juvenile, and an adult. The goal for the predators was to tag/eat as many sea turtle hatchlings as possible.

The last part of the lesson plan involved filling out a sea turtle anatomy worksheet that was created by the Minnesota Zoo. For this activity, students wrote out the different sea turtle parts, some of which were difficult for them (for example, the word "carapace"). If I could

implement this lesson again, I would use a simple sea turtle photo that would show the names of the sea turtle parts written alongside the illustration. It would then be the student's job to draw a line to the sea turtle parts, and the teacher would read each structure and function of a sea turtle, and then assist students with properly lining up their sea turtle parts to the appropriate words.

At the end of the lesson plan, the life cycle of a sea turtle was reviewed, the four stages were discussed, the students identified the threats to the sea turtle, and finally the students brainstormed how we can protect the sea turtles. Examples of ways that we can protect sea turtles include putting our trash in the correct waste receptacle, picking up after others on the beach, using reusable straws and cutlery, assisting baby sea turtles get to the ocean (with proper supervision), sharing with others the threats sea turtles face, and keeping a 10-foot distance from a basking, laying, or swimming sea turtle.

The assessment methods for this lesson plan included the first-grade teachers' feedback (via a letter about my implementation of the lesson plan), student assessment feedback (based on three distinct student performances), and a lesson implementation self-reflection. The student work analysis questions were as follows: "What does the student's work demonstrate about his/her proficiency with the requirements of the standard(s) targeted?," "What does the student's work demonstrate about the depth of his/her understanding?," "What does the student's work demonstrate about his/her ability to apply the knowledge to a task?,", and "What implications for planning and instruction are evident in the student's work?" The lesson implementation self-reflection focused on three examples from the lesson plan and reviewed what worked well, what needed improvement, and if there might be any potential revisions to the lesson plan.

Discussion

The Hawai‘i Island Hawksbill Project’s long-term goals of increasing the overall population of the hawksbill species by reducing negative impacts to nesting beaches, maximizing hatchling production, protecting nesting females, protecting hawksbill nests, monitoring hawksbills hatchlings , calculating nest success, and hatch success rates were accomplished during my internship. Data concerning nest success, hatch success, presence of female adult hawksbills, and hawksbill hatchlings on Hawai‘i island aided in identifying the active Hawai‘i island hawksbill nesting population. Efficacy of carrying out predator prevention and assisting hatchlings to the ocean reduced the potential threats to the Hawai‘i island population of hawksbills. Ongoing documentation of the natural moon phases and ocean current cycles helped with the prediction of sea turtle activity, and turtle nesting behavior documentation offered insight into individual nesting females’ behavior and assisted in foreseeing the likelihood of the female hawksbills’ return.

The Hawai‘i Island Hawksbill Project’s long-term goal of protecting the species, strengthening the population, and recording that work through monitoring and assessments of the hawksbill nesting activity on Hawai‘i island was achieved at known nesting sites. The major undertaking that had the most impact to me over the course of the project was tagging a new nesting hawksbill, since this added her to the trackable population of females. The return of nesting hawksbills to their natal beaches may suggest that populations on Hawai‘i island are in a stable state. Evidence of mitochondrial DNA suggests that the Hawai‘i hawksbills are distinct management units that require significant attention to the threats facing the Hawai‘i island population (Goas et al. 2020).

Increasing public awareness and educational outreach was another long-term goal that I participated in, this involved educating the community about the hawksbill population on Hawai‘i island. Stressing the importance of reducing marine debris on sea turtle nesting beaches brought awareness to the potential threats to hawksbills that might result in entanglement or digestion of harmful man-made products. At Hawai‘i island schools, public education regarding stewardship of beaches increased sea turtle conservation knowledge for members of the Hawai‘i community who may have had no prior knowledge of the sea turtles that comprise the Hawai‘i island marine ecosystem and, perhaps, it may have inspired future sea turtle conservationists.

Conclusion

The tangible skills that I gained during my internship experience with the Hawai‘i Island Hawksbill Project involved formal training working within a government agency ecosystem, knowledge about the hawksbill species, reading a lava terrain landscape, monitoring hawksbill nesting beach locations, identifying nesting hawksbill females, recording hatchlings' activity, and noting the environmental conditions. In any field work environment, there is a certain amount of grit that goes into accepting and following through with this physically and mentally challenging responsibility. My summer experience as a VIP was invaluable because it allowed me to obtain hands-on fieldwork skills with a Critically Endangered species. I now know that I can handle the physical requirements of fieldwork and maintain the mental capacity for successfully documenting wildlife activity. I would like to continue part of my career in wildlife rescue and rehabilitation, and work in the education field, teaching the next generation about science related curriculum and conservation ideals. I realized that while humans have done a lot of damage to the oceans, negatively impacting wildlife, we also have the capacity to create positive change in the environment by, for example, participating in beach clean-ups, assisting

wildlife that are in distress, and being mindful when building or renovating homes where wildlife habitat is crucial.

The opportunity to write, create, and teach my lesson plan at The Volcano School of Arts & Sciences was one of the most rewarding experiences of my graduate learning journey. I not only had the chance to work with a government/non-profit organization, but I was also able to take it a step further by bringing what I learned into a classroom environment. While in the classroom, I explained to students about the importance of sea turtle monitoring on Hawai‘i island, and this experience informed me that I would like to continue to work in the public awareness arena. With this knowledge I would like to be an informal science educator, teaching students about the way natural and physical sciences work.

Most importantly, I realize that I am my best self when I am out in Creation working on my own, or with a small team of people; nature is where community grows, and trust is strengthened among those who have shared values for the land and for the life that inhabits it.

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