Loko I‘a Kalo at Loko Ea

University of Hawaii at Manoa Hawaiian Studies 460: Hui Konohiki Practicum
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Abstract

The goal of this project targets the construction and management of a loko iʻa kalo to contribute to the community's sustainability. This project was based at Loko Ea fishpond in Haleiwa, Oʻahu. The importance of a loko iʻa kalo involves bringing two worlds together as one; makai and mauka. However, a lack of cultural knowledge and a limited amount of resources dealing with this type of pond makes it difficult to understand and manage a loko iʻa kalo. Recorded documents have proven that bringing these two worlds together to create one food source has improved the nutrients of the kalo and the fish (Costa-Pierce, 325).

The importance of a loko iʻa kalo, the process or methods used to construct and manage this type of loko, and the change of the practice will be looked at as an ideal backing to this cultural practice over time. Steps to reveal any information on loko iʻa kalo has involved literature research through Hawaiian cultural books and websites focusing on key words pertaining to loko iʻa kalo, and contacting people of all ages who are lawaiʻa (fisherman) or mahiʻai (farmer) experts known in the communities of Hawaiʻi to discuss the construction of a loko iʻa kalo and the process of growing kalo. As a result, the cultural practice of constructing and managing a loko iʻa kalo was extremely common in ancient Hawaiʻi, however was never documented. Today, there is no record of the process to construct or manage this type of pond. Through my research, records that have been published only describe a loko iʻa kalo. Through this project, Loko Ea now has 9 puʻepuʻe with kalo growing inside of the Keiki pond. Overall, I hope that my research will provide a learning environment that can teach community members and families within the district to effectively sustain themselves and be a leading example to other communities.

The idea of this project is to benefit the ecosystem as a whole ranging from humans, plants, and fish. Based on the large amount of space open to be utilized, my project was seen as an important aspect of the food production within this area. The purpose of this project is to utilize open space, expand the food variety at Loko Ea, utilize the fishpond's rich nutrient soil, provide for the community, and document from beginning to end the process of contructing a *loko iʻa kalo* for the community. Knowing the structure, management and cultural significance of a loko iʻa kalo is critical to the survival of the people of Hawaiʻi. The importance of a loko iʻa kalo, which involves bringing two worlds together as one; makai and mauka, can improved the nutrients of the kalo and the growth of the fish.

Table of Content

Figure of Content

Introduction

According to Kumukahi.org, "'O nā loko iʻa, ʻo ia kekahi mau mea hoʻohiluhilu o ka ʻāina, a ua kapa ʻia he ʻāina momona no ka nui o nā loko iʻa. Fishponds, loko iʻa, were things that beautified the land, and a land with may fishponds was called a 'fat' land (ʻāina momona)." This statement makes me think of how important fishponds were in ancient times and its ability to bring different life forms together. Often times Hawaiian people believed that fishponds were a type of piko that connected the land and ocean into one cycle of life. Fishponds were commonly affected by what happens mauka and what happens makai. Prior to 1848, the land (including natural resources, fishponds, communal and spiritual centers) belonged to the king. No one was allowed to claim private ownership but instead be stewards to the land. The king distributed land with other lesser chiefs to care-take and rule. However sacred resources such as fishponds were kept under the king's direct control (Costa-Pierce, 31). Even the king could see how valuable and significant fishponds were for the production of food.

In a single ahupuaʻa, one can have six different types of fishponds; loko hāpunapuna, loko puʻuone, loko iʻa kalo, loko wai, loko ʻume iki, and loko kuapa. Through my research, I focused specifically on the construction of a loko iʻa kalo and its management. "Taro and fish were the staples of life. The abundance of life came from water, and thus, the word for wealth is waiwai" (Wyban, 93-94). A loko iʻa kalo has the ability to bring mauka and makai elements into a single fishpond. The Ancient Hawaiian State: Origins of a Political Society states that a loko iʻa kalo is a freshwater loʻi in which both taro and fish were raised (Hommon, 84). Hawaiians planted kalo in terraced fields, flooding the terrace with freshwater once the plants were placed. Areas between the plant mounds created channels as a habitat for the fish (HistoryHawaii.org).

This project was based at Loko Ea fishpond. This fishpond is located in the *ahupuaʻa* (land division) of Kawailoa, which lays in the *moku* (district) of Waialua on Oʻahu. This area was famous for the abundance of ancient hawaiian farmers and fishermen that would fish and harvest to sustain their families. It was anciently known as the "oracle center" of Oʻahu because of its impressive fields of *kalo* (taro). This fishpond is a *loko puʻuone* (pond near the shore formed by sand) that is fed by Kawailoa springs. It was a favorite pond to chief Kakuhihewa for the fat mullets, and he would send his runners to get fish when he demanded of it. It was also a favorite pond to chiefess Queen Kaʻahumanu (Lokoea.org).

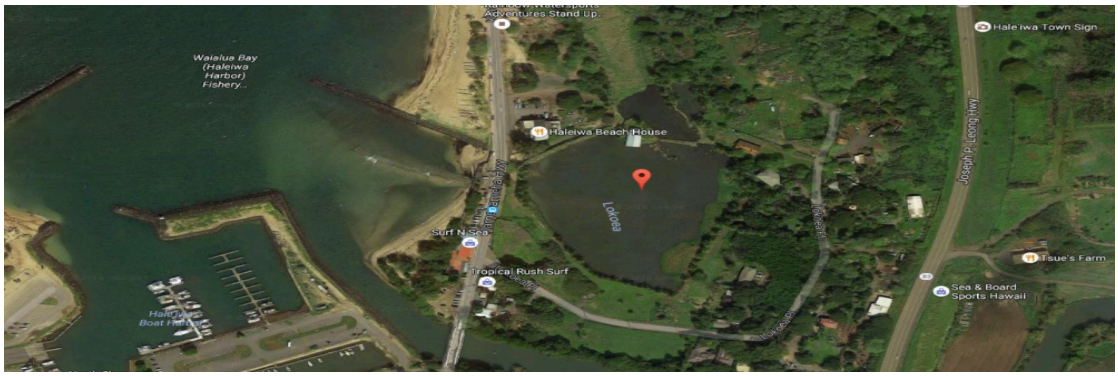


Figure 1: Arial map of Loko Ea fishpond in Haleiwa, Oʻahu

The non-profit organization, Mālama Loko Ea, caretake this fispond. Mālama Loko Ea was founded by a small group of construction workers who came to clean up this area. Overtime, these men wanted to make this deed permanent and therefore created the non-profit organization Mālama Loko Ea (Kaleoaloha, 2017). From there on, Mālama Loko Ea has leased the land under the Bishop Estate through Kamehameha Schools outreach programs and continue to restore this fishpond (Lokoea.org). Some of the work that Mālama Loko Ea has done and continue to work with include weeding, removing invasive fish and plants species, planting native Hawaiian plants, drenching, water quality testing, pond stocking, rebuilding rock walls, and growing *limu* (seaweed). This organization networks with the community and several schools through outreach programs, community work days, and internships (Kaleoaloha, 2017).

Methods

Literature:

The literature research and resources I used to collect factual information for this research project came from cultural websites and Hawaiian cultural books; both online and hardcopy. At a surface level, I researched key words pertaining to loko iʻa kalo on Google.com. Sites that discussed information about Hawaiian loko iʻa kalo were looked through.

I reached out to the local librarian at UH Manoa Hamilton library, Kapena Shim. Together we looked at Googlebooks.com using the key word loko iʻa kalo. From there appeared a list of books that discussed loko iʻa kalo anywhere within the book. With the listed books, we took the names of each book and researched them in the UH catalog Voyager library and requested them through Hamilton library: Pacific Studies collection.

Next we searched for resources in Voyager using specific key words relating to this project; loko iʻa kalo, loko iʻa, and kalo. Once we found several resources to look through, we expanded our search to other key words. In the information section of a book on Voyager, there is subject paragraph that suggest other related subjects to what you are looking for. We took some of the related subjects and expanded our search to looking for resources involving fishponds in Hawaiʻi, aquaponics, taro, and loʻi.

During my research I analyzed the research that I find and understood the content of each literature and resource. All information that mentioned the construction, management, the significance, and any other relating information to loko iʻa kalo was recorded into Microsoft Word document. I also recorded all resources that I looked through with its title, form (online or hardcopy), and author or address into an Excel document.

Interviews:

The interview recording methodology I used to collect the field data for this research project starting with contacting people of all ages who are familiar with cultural lawaiʻa (fishery) practices, cultural mahiʻai (farming) practices, have knowledge of the land and loko iʻa kalo, and have any techniques to building puʻepuʻe or growing kalo. Each candidate was selected to talk story with by their profession and their cultural background with lawaiʻa or mahiʻai. I also looked at the way each individual was referred to be identified in his or her community with knowledge of historical wisdom in land, families, practices, and land use.

These interviews were a casual style of talking story and learning from one another. Based on each candidate's profession or knowledge, they were asked foundational questions involving any knowledge of loko iʻa kalo, making a loko iʻa kalo, where they are found, and people who may have further knowledge of this practice. The candidates who worked a lot with kalo were asked questions on how to grow, prep, and plant kalo. The candidates who were familiar with lawaiʻa practices were asked questions on identifying fish varieties in a loko iʻa and managing a loko iʻa.

After each interview, records were documented in an Excel document of the name of the person, their profession, and all of the knowledge that they shared with me during our discussion. Each candidate was thanked for their time and participation with a bag of laulau or a bottle of chili pepper water.

Kalo Varieties:

The research method I used to choose the type of kalo I planted was by using Kupunakalo.com. This website shares knowledge of over 80 species of kalo native and introduced to Hawaiʻi. Under each kalo variety is a descriptive introduction of its use as food, distribution, general characteristics, petiole, leaf blade, corm, and fun facts about its deeper meaning of the plant. Each native kalo to Hawaiʻi and its introduction was recorded into an Excel document. After talking story with my interview candidates, few suggested that I use iʻa kalo (fish kalo) in my loko iʻa. In a separate Excel document, all iʻa variety and ocean related kalo were recorded.

From Ka Papa Loʻi o Kānewai, located at Kamakakūokalani UH Manoa, four iʻa and ocean varieties of huli kalo were donated to this project. These varieties included ʻohe, ʻeleʻele kūmū, ʻeleʻele mākoko, and oʻopukai. The lau (leaf blades) were cut off the top of the huli. Each variety was placed in a bucket of cold water until new roots were growing from the bottom of the huli. This was a week after receiving them from Ka Papa Loʻi o Kānewai. They were put in an area where it can catch the morning sun. Key Project, located in Kaneʻohe, donated a bucket full of freshly cut moi variety of kalo to this project as well. The lau were cut off the tops of each huli and the corms were cut off from the bottoms if they were not cut properly. The huli were placed in two buckets with water and put in an area where it can catch the morning sun. They were left in the buckets for a week before relocating. The huli that had new roots growing were placed in an empty bucket and taken to Loko Ea to plant. All donors were given a couple of bags of laulau as an appreciation for the huli kalo.

Field Work:

The on-site field work methodology I used to construct a loko iʻa kalo started with taking site observations around the perimeter of Keiki pond. The goal was to find an area clear from any trees or branches dropping into the plotting zone and near the fresh water springs to utilize the cool temperature and flowing water. Two sites were chosen to be planting zones within Keiki pond. Zone 1is located in the center of the pond having zero surrounding vegetation to damage the kalo but is the deepest part of the pond. Zone 2 is located near the back right corner of the pond nearest to the Kū stone. This zone is shallow and has a perfect temperature and water flow coming from the freshwater springs, however two large coconut trees hang near to this zone and drop small coconuts into the pond.

Once both zones were plotted, zone 2 was visually marked with pegs and string. The perimeter of this zone was 18ft by 18ft placed 2ft away from the walls of Keiki pond. A tide meters were place in each zone measuring the inches of the depth. At 11:00a.m. and 3:00p.m. the tide in the pond was recorded twice a week. These numbers helped to determine how high the puʻepuʻe needed to be built from the pond's floor. Three styles of puʻepuʻe were tested near zone 2 and observed for 2 weeks on how long they could hold its structure and the behavior of the fish to the next development in the pond. In zone 2, 2 rows of the puʻepuʻe style that was most successful were built using rocks around the property of Loko Ea and the sediment inside Keiki pond. These puʻepuʻe were observed for 1 week until planting the huli. Records of the behavior of the kalo and behavior of the fish were taken note of. These observations were recorded in an Excel document.

After 3 weeks of observations, the kalo were very small and stayed below the water surface, and the puʻepuʻe were gradually siding between the rocks decreasing the height of the mounds. Due to the poor results of the kalo, efforts were made to move the planting zone to the shallowest area in the pond. Zone 3 was located in the far right point of Keiki pond near the Luahine cave. This zone had a depth that was mid-calf deep. 9 puʻepuʻe were built and planted during the same day and each puʻepuʻe had 3 huli planted. Observations on the strength of the puʻepuʻe, behavior of the kalo and fish were recorded in an Excel document. All focus during the remainder of this project were targeted on zone 3.

Kaulana Mahina:

The field work method that I used to plan out my schedule of activities needed to be done was organized by following the Hawaiian lunar calendar. For many years, Hawaiian people have used the 30-night lunar cycle to determine, among other practices, when to plant crops and fish (see figure 2). I laid out my visits to Keiki pond and based on the Hawaiian moon calendar I organized my activities. Two of the important moon phases during my project were the Māhealani and Laʻau moons. During these phases I planted huli. Considering that Keiki Pond was already stocked with many native fish, I did not worry about introducing baby fish to the pond. During the remaining moon phases I prepped the plots that were going to be planted in and maintained the surrounding area by weeding and re-piling sediment to the puʻepuʻe.

Moon Phase	Farming	Fishing
Hilo	Excellent day to plant.	Beach and reef good fishing.
Hoaka	Promising day for planting.	Torch fishing goof on reef.
Kūkahi	Plant sweet potatoes and upright trees.	Good daylight fishing on reef.
Kūlua	Excellent day to plant ʻuala, kalo, maiʻa, and trees.	Morning fishing good on low tide.
Kūkolu	Huli or slips planted with produce 3 shoots.	Fish abundant during dry season.
Kūpau	Final evening that ʻuala and kalo can be planted.	Fair fishing on reef.
ʻOlekūkahi	Unproductive planting.	Fishing not good.
ʻOlekūlua	Most challenging day to plant.	Fishing is not good.

ʻOlekūkolu	Mulching, weeding and pruning best farming activities today.	Torch fishing near shore will be productive only in evening.
ʻOlepau	Good for planting ʻulu, eggplant, and other vegetables.	Not a good day for fishing.
Huna	Plant gourds, ʻuala, pumpkin, and corn.	Expect good night fishing today.
Mohalu	Excellent planting for anything but trees.	Fishing will be good.
Hua	Plant anything that bears fruit.	Good fishing, especially at sea.
Akua	Plant ʻuala, kalo, gourds, bananas, and corn.	Good fishing, especially at sea and on reefs in evening.
Hōkū	Excellent for planting all kinds of plants but kalo and bananas.	Good fishing, especially at sea, not in shore.
Māhealani	Plant bananas in evening. Good planting for anything.	Excellent fishing expected today.
Kulu	Plant bananas, and potatoes and melons in evening.	Good deep-sea fishing is expected.
Laʻaukūkahi	Plant bananas but no ʻuala.	Fair fishing. Best at sea
Laʻaukūlua	Good for cultivating but not planting.	Fair fishing at sea.
Laʻaupau	Good day to plant anything but vines.	Morning fishing fair at sea.
ʻOlekūkahi	Not good for planting.	Fishing unproductive.
ʻOlekūlua	Not good for planting.	Fishing is not good today.
ʻOlepau	Plant bananas.	Good offshore fishing can only be expected.
Kāloakūkahi	Good for planting long or tall plants.	Good offshore fishing, excellent for shellfish.
Kāloakūlua	Good for planting anything but potatoes, melon, and bananas.	Good reef fishing at night
Kāloapau	Plant bamboo and sugar cane.	Excellent torch fishing in the evenings on the reef due to low evening tides.
Kāne	Excellent for planting anything.	Good reef fishing with poles or torches.
Lono	Excellent for planting anything.	Excellent for pole fishing, torch fishing, and diving.
Mauli	Excellent for planting anything.	Fishing is good for all styles.
Muku	Bananas planted in evening.	Excellent for all kinds of fishing. The tides are low which trap fish in tide pools and loko iʻa.

Figure 2: Prince Kūhio Hawaiian Civic Club Hawaiian lunar calendar

Results

Literature:

This semester I identified 14 loko iʻa kalo literature sources. 64% were cultural hardcopy books from the UH Manoa Pacific Collection with information of the history and description of a loko iʻa kalo. Out of the 14 literature sources, 29% were online cultural sites and 7% were pdf documents from the Hawaiian Studies Loko Iʻa class through UH Manoa. Within these literature resources three themes stood out; the definition of a loko iʻa kalo, the significance, and the types of iʻa that grew in a loko iʻa kalo.

Loko iʻa kalo or freshwater kalo fishponds were one of the four themed ponds which grew in an ahupuaʻa that Hawaiians categorized. Others included other freshwater ponds (loko wai), brackish water ponds (loko puʻuone), and seawater ponds (loko kuapa) (Costa-Pierce, 33). A loko iʻa kalo, also sometimes called a loko loʻi kalo, were modified taro patches to include aquaculture (Kawelo, 31). Basically, a freshwater loʻi where both kalo and fish were raised and harvested. This type of pond was located upland to cultivate kalo and simultaneously grow a selective range of fresh and brackish water iʻa (Keala, 2). Similar to other agricultural plots, loko iʻa kalo were fed and drained from a system of water ditches. It is believed that these ponds arose originally from shallow ponds created by the diversion of stream runoff for the irrigation of wetland kalo and over time the Hawaiian people added aquaculture to the design of these ponds (Kawelo, 33). The diversion of stream run off for the irrigation of kalo is what prompted the agricultural development in fishponds. As water made its way from the mountain to the sea, freshwater from the clean mountain stream was channeled into loʻi kalo. The kalo was planted in mounds or puʻepuʻe. Once the loʻi was flooded, the channels between each puʻepuʻe created a perfect habitat for the fish to swim through and feed from the ripened talks of kalo (Costa-Pierce, 325).

The idea of an integrated system, such as a loko iʻa kalo, is used all around the world and throughout history. Here in Hawaiʻi, the importance of having an aquaponics within the community plays a large role to the culture. Kalo and fish were the principles of life, and still are today (Wyban, 93-94). Fish were used for subsistence, ceremonial purposes, and managed carefully to ensure that the resources were not abused (Keala, 6). Kalo on the other hand has been a key resource for the self-sufficiency of the people and holds an important genealogical role in the kumulipo as Haloanakalaukapalili, Hawaiian's first ancestor (Since Forever, 1). There were two chiefs that were associated with fishponds; the aliʻiʻaimoku and the aliʻiʻaiahupuaʻa (Kawelo, 35). Prior to 1848, all land in Hawaiʻi, including its natural resources, fishponds, heiau, communal and spiritual centers, were cared for under the aliʻiʻaimoku's control. Many times the aliʻiʻaimoku divided the land amongst the land aliʻiʻaiahupuaʻa, but kept sacred resources under their direct control. The fishponds that were given to the aliʻiʻaiahupuaʻa often left the control of smaller agricultural fishponds to the makaʻāinana. This system created a network that extended out to family groups and pond workers living in the ahupuaʻa. All harvests from the fishponds were distributed by the aliʻi to the community in a politically institutionalized manner (Costa-Pierce, 31).

This type of sociocultural system contributed a great amount to the development of aquaculture and agriculture networking. The resources from a loko iʻa kalo gave life to an entire family. When one was hungry, the wife caught a few fish from the pond, and

picked some lau of the kalo to relieve their hunger. Sometimes when one woke up in the mornings and was eager to eat, fish wrapped in lau of the kalo was brought to the table. The kalo leaves would have wilted and he fish would be shaped like pig tusks and were laid in a food bowl to be eaten until full. The convenience of having a loko iʻa kalo allowed the people of old Hawaiʻi to lack nothing (Wyban, 108). Loko iʻa kalo were also convenient when families were visited by malihini or the haku ʻāina within the night. One would quickly get some fish that had fully grown to adult size and pound a bowl of poi. The poi and fish were served to the malihini or haku ʻāina as a generous hospitality to their guest (Wyban, 108).

Some of the most common fish that grew in a loko iʻa kalo included ʻōpae, ʻoʻopu, āholehole, awa, ʻamaʻama, and limu kalawai (Niau and Hirai, 16). Each carried a significant role to the Hawaiian community and culture. One way to get fish into a loko iʻa kalo was by stocking. One could gather juveniles in brackish water kahawai or outside of the pond, usually during the months of January to March when baby and juvenile fish were bountiful, using an ipu or dip net (Keala, 4). Sometimes one would carry the fish in an ipu for miles inland to stock their pond. Other ways fish got into the pond was by swimming up stream into the mākāhā. However, sometimes undesirable fish such as barracuda and tilapia would enter into the mākāhā (Keala, 4). It is most likely that stocking practitioners observed that fish could survive in these types of ponds and deal with the harsh transition from salt to fresh waters. They also realized that the fish grew so well from feeding on the insects and ripe leaves of the kalo that they were able to improve the kalo growth due to fewer pests and continual grazing activity (Costa-Pierce, 325). Loko iʻa kalo were commonly cared for by the makaʻāinana on their own property. A single ʻohana was responsible for the management and control of the loko iʻa kalo. The ownership and responsibilities of this practice was passed down from generation to generation (Keala, 4).

Interviews:

Throughout my internship and research, I interviewed 9 people in all different communities on Hawaiʻi and Oʻahu. Majority of my interviewees were *mahiʻai* (farmer) people who work closely with kalo or have knowledge of kalo. Overall, I reached out to experts in mahiʻai, lawaiʻa, and wise about the Hawaiian cultural practices. All interviews were conducted face to face in a casual talk story setting. Through my interviews three major themes were brought to my attention, which include the direction of planting kalo, tips to maintaining the kalo when planted, and the benefits of using fishpond sediment.

For many people kalo is a life form of the Hawaiian people and is considered to be the eldest sibling of a Hawaiian's genealogy. Through my interviews, 5 people shared the process and tricks of planting kalo. Kalo enjoys the cool temperature of the water in which it grows in. The cooler the water, the happier the kalo. One key tip to having a loʻi is to have flowing water so that the kalo and breathe. When creating the rows to plant, one must plant in the direction that water flows. The reason for this is to allow the water to continue to flow in its original path without blocking or cutting off water circulation (Kalealoha, 2017). When one is ready to plant, they need to decide the reason for planting. Most huli, depending on how one prepped their kalo stalks, will have a "V" stem or a kalo with two stems growing out of the center. Mahiʻai like to imagine this "V"

being the life form for the next generation. If one wishes to have plenty kalo shoots, they will plant the kalo with the "V" facing East to West (Aranaydo, 2017). When the sun rises in the East and travels to the West, it is going in between the "V". The manaʻo behind this is the huli being wahine and the sun being kāne. When the kāne passes between the wahine, she is fertile and will produce more babies (Souza, 2017). If one wishes to grow for big kalo, they will plant the kalo with the "V" facing North to South with the sun traveling over the huli. The manaʻo behind this is the leaves of the kalo are exposed to the sun throughout the entire day. They are facing the sun when it rises and sets, therefore receiving a lot of nutrients to grow (Lee-Agcaoili, 2017).

Many people feel that once kalo is planted, you can leave it and it will grow on its own. However, several people who I interviewed beg a difference when planting wet land kalo. Due to the fact that you want your dirt to be loose enough for your kalo to grow and root in but also hard enough to stay together can sometimes make it difficult to find the perfect balance. Many mahiʻai people share that they have to continually re-pile their puʻepuʻe mounds or their loʻi walls because of the water pushing up against the sides causing the dirt to run down. One does not want the roots of their kalo to show out of the dirt because it will tell the kalo that there is no more room to grow bigger (Kalealoha, 2017). Sometimes the top surface of the puʻepuʻe will be exposed to the sun too much and will begin to crack. If there is cracking in the puʻepuʻe, the nutrients that is circulating around the kalo will release (Pacarro, 2017).

Often times in fishponds, there is a high nutrients level in the soil. This is caused by clean fresh water flowing through the pond to flush out any debre, natural mulching from the leaves that fall into the pond, and the fish poop. Studies at Waiāhole fishpond in Keaukaha have tested with their fishpond sediment to grow kalo on one of the puʻu honua. This study tested three growing patches; one with 100% sediment, second with 50% sediment and 50% dirt, and third with 100% dirt. Overall, all were growing however the first and second patches were thriving more with the fishpond sediment (Staff-Waiāhole, 2017). Studies at Loko Ea have shown that the nutirent levels in Keiki Pond are the highest throughout the entire pond. The reason this pond needs to have the highest nutrient levels is because it nurses the baby fish who have small immune systems that are still too weak to fend for themselves (Lum, 2017). This is very similar to babies vs. adults.

Field Work:

During my internship I gathered weekly tide measurements resulting in 12 days total of collecting. Meter 1 resulted in a depth ranging from 17 to 24 inches at high tide and 16 to 23 inches at low tide. Meter 2 resulted in a depth ranging from 24 to 32 inches at high tide and 23 to 30 at low tide. As a conclusion, Meter 1's neutral tide was 22 inches at high tide and 16 inches at low tide. Meter 2's neutral tide was 30 inches at high tide and 23 inches at low tide. These heights were converted into a scale that shows how much the tide increased or decreased from its neutral state (see figure 3 and 4). These measurements were compared with NOAA's tide predictions at Haleiwa on the same day and times (see Figure 5). As a result, during low tide majority of the time the tide of the pond was much higher than the ocean. When the tide was high, majority of the time the tide of the pond was either equal or lower.

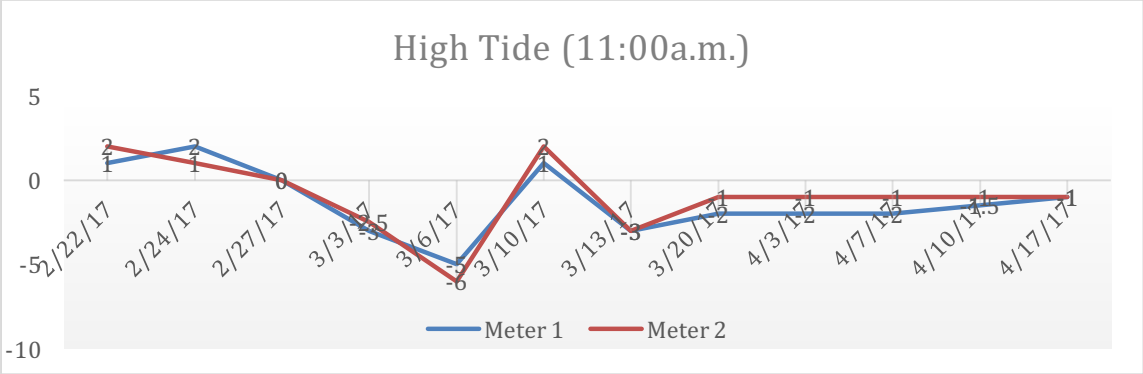


Figure 3: High tide chart of meters inside Keiki pond

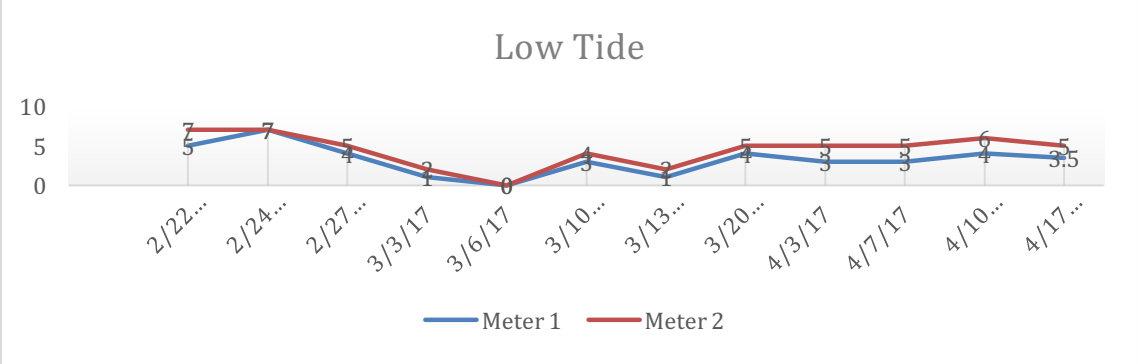


Figure 4: Low tide chart of meters inside Keiki pond

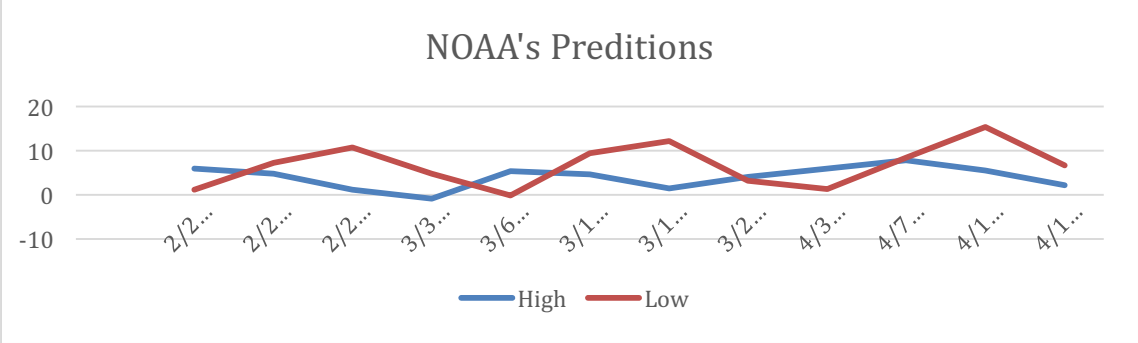


Figure 5: National Oceanic and Atmospheric (NOAA) tide predictions

Within my research, I constructed 4 different types of pu‘epu‘e mounds inside of Keiki Pond and each type carried its own interesting characteristic. Overall, one type of pu‘epu‘e was successful. A graph shows the different types of pu‘epu‘e I tested with and their results (see Figure 6).

Pu‘epu‘e Design	Design Explanation	Observations

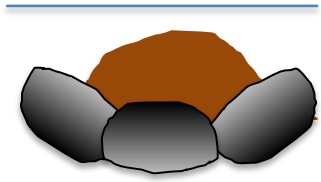
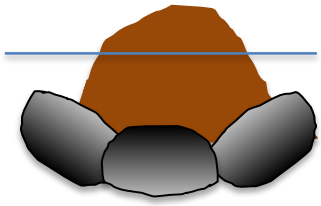
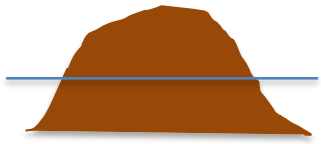
	Carefully piled sediment in one area to create a puʻepuʻe. Puʻepuʻe was 3 inches below the water level. The sediment could not pile higher without it sliding down the sides	• Held together for 1 week but became half the height • Fish enjoyed swimming over this puʻepuʻe • Fish ate from the puʻepuʻe sediment
	Placed large rocks in a circle and filled the middle with sediment. Carefully piled sediment on top until it creates a puʻepuʻe. The puʻepuʻe was 3 inches below the water level. The sediment could not be piled higher without it slipping away	• Held together for 1 week with little decrease in puʻepuʻe size • Fish were attracted to this puʻepuʻe immediately • Fish ate the algae from the puʻepuʻe rocks and sediment • Holds shape but sediment is loose and thin
	Placed large rocks in a circle and filled the middle with sediment. Carefully piled sediment on top until it creates a puʻepuʻe. The puʻepuʻe was 2 inches above water level.	• Held for 3 to 5 minutes above water • Sediment slid off the puʻepuʻe easily for the top sediment to dry
	Carefully piled sediment in a shallow area to create a puʻepuʻe. The puʻepuʻe was 5 inches above the water level. The height of the puʻepuʻe above water level was larger than the height below water level.	• Held for 1 week with minor decrease in size • Sediment stayed above water level • Side of puʻepuʻe needed to be built weekly

Figure 6: Puʻepuʻe style construction and results.

Discussion

Over a one semester time period, this project explored the development of aquatic food production in Hawaiʻi with a main focus on loko iʻa kalo construction and management. My research questions targeted the techiques of building a loko iʻa kalo, the significance of this resource to the people of Hawaiʻi, and the benefiting outcomes for the fish and the kalo. The amount of effort put into this project resulted in over 60 hours within a one semester time range. Through my research 14 literature resources were found to have mentioned loko iʻa kalo or other relating topics. There is a few amount of resources that share the concept of a loko iʻa kalo, however a limited amount of resources that significantly explain the construction and management of this type of loko.

Casual talk-story interviews with 9 expert cultural practitioners classified the techniques of growing kalo and managing a loko iʻa. All interviews strongly agree a loko iʻa kalo is something that must be babied and managed daily for the first few stages of the

kalo's life. The existence of a loko iʻa kalo has become less of a primary practice due to the introduction of grocery stores, and responsibilities that require maintenance away from home. No families today reveal to have or mālama a running loko iʻa kalo in today's society.

The sediment that was being used in this project was very thin and could easily slide away. This made it very difficult to use and play with because it could not hold a solid form. Even with rocks surrounding the sediment that was piled would slip away. From the sediment being very thin, this meant the puʻepuʻe would not last long enough to hold its state with continual water ripples rubbing on the sides. As a result of this failure, the planting zone was moved to an extremely shallow zone. The sediment was a success to remain above the water level with little maintenance to be done to the puʻepuʻe weekly. The kalo were able to grow more comfortably in this shallow zone meaning that the puʻepuʻe mounds and the kalo must be above the water level to grow productively. The kalo that was able to survive the limited amount of salinity in the water and air was the ʻohe and moi variety. This means out of the 5 kalo varieties planted during this project, 2 were capable of surviving and growing in a loko iʻa kalo near the shoreline. Overall, the use of sediment from the loko iʻa for building puʻepuʻe will not hold in place unless there is a limited to zero water disturbance. However, the nutrients in the sediment improve the growth of the kalo.

For the future, more puʻepuʻe styles need to be tested in different loko iʻa types as well as a comparison of water quality, sediment quality, and the growth rates of the kalo and fish in a loko iʻa kalo and in a loko iʻa. This I recommend to anyone who would like to further research in depth the benefits of a loko iʻa kalo and the methods that were used to construct one. Overall, I feel this project was very successful in being a starting point and a basic guide to loko iʻa kalo. I strongly feel that having the capability to manage and grow both fish and kalo in one plot is an expert of both mauka and makai.

Due to loko iʻa kalo being such a common thing to have in your backyard during ancient Hawaiʻi may be the reason it was never recorded or documented to its full potential. Another factor may be that families grew moved away from their homes and these types of ponds were left to be unmanaged and thick vegetation grow covered them. One take home lesson I gained from this project is to document everything that is done and the process of it being done because in the situation that I was in where there was a limited amount of information on loko iʻa kalo, my project becomes a resource or guidebook for future researchers to use when constructing a loko iʻa kalo.

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