# Pacific Aquaculture & Coastal Resource Center: Creating the Children's Learning Center and gaining experience with aquaculture practices

A REPORT SUBMITTED TO THE GRADUATE DIVISION OF THE
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IN
TROPICAL CONSERVATION BIOLOGY AND ENVIRONMENTAL SCIENCE
PROFESSIONAL INTERNSHIP TRACK

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**Abstract**

My University of Hawai‘i at Hilo professional internship with the Tropical Conservation Biology and Environmental Science (TCBES) program was based at the Pacific Aquaculture and Coastal Resources Center (PACRC) located in Keaukaha on the island of Hawai‘i. The facility’s long-term goals are to provide infrastructure for world-class aquaculture and marine science programs at the University of Hawai‘i at Hilo and to support commercial aquaculture, fisheries, and conservation. PACRC promotes excellence and innovation in interdisciplinary scientific research, public policy initiatives, outreach activities, and education. At PACRC, I gained valuable aquaculture experience as I served as an intern in live feeds production and in the bivalve hatchery. I assisted in the day-to-day functions needed for the successful husbandry of various species of oysters, microalgae, and rotifers. Knowledge of how aquatic systems work is an essential skill for someone in my academic career path, and learning the techniques taught at PACRC will benefit me greatly in my future endeavors. During my professional internship, I also worked on the Children’s Learning Center project, aiding in the renovation and transition of PACRC’s pavilion space into a new Children’s Learning Center facility. I directly helped in the renovation process while also creating educational resources that will be used in the space once it is completed. I worked alongside my mentors Dr. Maria Haws and Sydney Gamiao involving community outreach and planning for the future use of the Children’s Learning Center while also briefly teaching an after-school program in the unfinished space. Overall, this professional internship provided me hands-on aquaculture experience while also exposing me to education and outreach opportunities.

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TCBES – Tropical Conservation Biology and Environmental Science

PACRC – Pacific Aquaculture and Coastal Resource Center

CLC – Children's Learning Center

## Introduction

### *Background*

The practice of rearing aquatic animals, known as aquaculture, has been documented around the world for thousands of years (Costa-Pierce 1987). Aquaculture and integrated farming systems in ancient Hawai‘i demonstrated diverse and sophisticated technologies that exhibited great development in the farming field. Although Hawaiian aquaculture systems are only 1,500 to 1,800 years old (Costa-Pierce 1987), Hawai‘i appears to be one of the originators of mariculture (seawater farming) with no other ancient culture recorded using oceanic resources in a similar manner.

Fishpond cultivation was a large and complex part of food production and trade economy in Hawai‘i. The political aspects of this socio-cultural system allowed for the growth of our expansive present-day aquaculture-agriculture network. In the late 18$^{th}$ century, approximately 360 fishpond systems existed across Hawai‘i which produced approximately 900,000 kg of

fish/yr (Costa-Pierce 1987). The arrival of Captain James Cook in 1778 brought many changes to Hawai‘i including the spread of diseases, the collapse of traditional authority in Hawai‘i, and the disruption of relationships with native land. The continued European landings resulted in a massive population decline of native Hawaiians, the disruption of traditional labor systems, and an increase in development in areas where aquaculture and agriculture systems once persisted (Suryanata & Umemoto 2003). Only twenty-eight fishponds were in production by 1977, and eight years later, only seven fishponds were in production producing approximately 15,000 to 20,000 kg fish/yr (Costa-Pierce 1987). However, to this day fishponds continue to have profound cultural significance and many fishponds have been revitalized contributing to sustainable aquaculture in Hawai‘i.

In 2010, aquaculture in Hawai‘i was a $30 million dollar industry that created many local jobs, replaced a portion of seafood importation, and grew the state’s export earnings (Arita & Leung 2014). Nevertheless, abroad imports from commercial fisheries have been historically the primary source of food fish supply in Hawai‘i in spite of the high importation costs and the reduction in quality and freshness (Arita & Leung 2014). Hawai‘i residents consume double the amount of seafood per capita when compared to the rest of the nation, and the rising demand for fishery products may soon fall short of wild fishery capture harvests (Hawaii Department of Agriculture 2000a; Kam et al 2003; Suryanata & Umemoto 2003; Loke et al 2012). An increase in aquaculture production may help solve the supply and demand issues that Hawai‘i may experience in the near future.

Consumption, research, sale, and restoration are all reasons for farm raising aquatic species. As of 2003, there are 35 plant and animal species being farmed for research and commercial production in Hawai‘i, with seaweed (*limu*) leading in revenue followed by shellfish

(Suryanata & Umemoto 2003). Besides consumption, oyster culture is important from an ecological perspective. Oysters form reefs in temperate areas, reduce sediment, provide habitat, and act as an important part of the food chain. As filter feeders, oysters are able to pump water through their gills trapping food, nutrients, sediment, and chemical contaminants. This process could mitigate water quality issues; helping clean our nearshore Hawaiian waters and elsewhere globally.

Hawai‘i has many attributes that favor marine aquaculture including its ideal nearshore water conditions, a large market demand for seafood products, and a vast local knowledge of fisheries science and production that would benefit homegrown production. Hawai‘i is also home to one of the five regional aquaculture centers in the United States, the Center for Tropical and Subtropical Aquaculture (CTSA), giving Hawai‘i an advantage producing innovative aquaculture research (Suryanata & Umemoto 2003). With these resources, Hawai‘i can become as food secure, sustainable, and self-reliant as it once was.

### *Purpose of the Professional Internship Project*

My University of Hawai‘i at Hilo professional internship was based at the Pacific Aquaculture and Coastal Resources Center (PACRC) on the island of Hawai‘i. This site, adjacent to the port of Hilo, serves as the University of Hawai‘i at Hilo’s aquaculture facility. The University of Hawai‘i has an impressive aquaculture resume having been involved in many pioneering research projects. My professional internship purpose was to aid PACRC in their mission to support commercial fisheries and maintain world-class aquaculture and education programs.

### *Graduate Student Learning and Professional Development Objectives*

As a graduate student, I set many learning and professional development goals for myself during my academic career. Some of the personal goals I wanted to achieve during my graduate experience were to improve my networking skills, make connections with conservationists in my field, build my resume and curriculum vitae, gain knowledge that extends beyond that attained at the undergraduate level, improve writing and oral presentation skills, and improve my critical thinking, creativity, and effective communication in science skills. My personal goals were matched with professional goals such as to further my education in regards to conservation, gain experience working in education and outreach, gain boat hours leading to achieving more boating certificates and licenses, increase my hands-on experience in marine science field research, learn how to properly set up and maintain tanks (mainly for aquaculture purposes but also helpful for other research or aquarium positions possible in my future), improve my ArcGIS skills, improve my ability to interpret scientific literature, and increase my knowledge in general boating safety and operations.

### *Professional Internship*

#### *Role*

As an TCBES Professional Intern at PACRC, I worked with shellfish in the facility's bivalve hatchery, assisted with live feeds production, and assisted on a community outreach and educational program. In addition, I worked on other projects as opportunities arose such as oyster collection, resource creation, job shadowing, and assistance in pavilion renovation tasks.

*Responsibilities*

Bivalve Hatchery

- Clean microalgae tanks
- Clean oyster bins
- Make nutrients for microalgae culture
- Prepare and feed PACRC organisms
- Count and monitor dead oysters
- Screen (or separate) oysters for sizing purposes or sales
- Monitor water parameters for oysters
- Organize equipment
- Clean storage container lab
- Carpentry and plumbing
- Creation of standard operating procedures (Appendix A)
- Learn shipment procedures

Live Feeds

- Monitor and maintain water parameters in rotifers including salinity, pH, ammonia
- Clean equipment and tanks
- Organize equipment
- Set up and breakdown of tanks
- Calculate ChlorAm-X and sodium bicarbonate for adjusting pH and ammonia levels

Children's Learning Center

- Create educational resources
    - Posters, Games, Outreach materials (Appendices B, C)
    - Collect nearshore reef species pictures
- Help with community outreach
- Attend meetings and seminars
- Assist in pavilion renovation
- Create pavilion schematic
- Shadow PACRC employees to gain full understanding of the facility
- Draft emails, surveys, and forms for contacting K-12 teachers (Appendix D)
- Visit Mokupāpapa Discovery Center for exhibit ideas and consults

Dr. Maria Haws' Aquaculture of Fishes class

- Attend class and labs to learn more about aquaculture
- Assist in set up and break down of labs if needed
- Take techniques learned in class and apply them in the hatchery and Thursday kid's (*keiki*) program (shipping, inserting and checking fish tags, etc.)

Manamoi O Hanakahi – Thursday After School kid's (Keiki) Program

- Create a flyer for the program (Appendix E)
- Set up and break down class
- Prepare resources used for the class

- Prepare lesson plans
- Teach children aquaponics and aquaculture
- Ensure safety of students and teachers

*Description of Starting Deliverables*

In quotation below are the proposed deliverables expected from all TCBES professional internship track students. Following the quotes are the methods discussed pre-internship with my advisor Lisa Canale of how I will achieve my TCBES deliverables. How well I completed or surpassed my original deliverables will be discussed in the outcomes portion of this report.

> "Engage in meaningful and challenging work. The TCBES Professional Intern will take part in a project that allows for their contributions to be collaborative. The Professional Intern will undertake a large project that allows for them to contribute in great depth and scope to an organization, with the opportunity for them to foster their independence and creativity, expand their knowledge on of the conservation issues associated with the project and mentoring agency."

The PACRC project that I proposed to engage in from the beginning months of my internship was to lead on the creation of the Children's Learning Center. As I worked on the Children's Learning Center, I also committed to assist in various projects within PACRC's oyster hatchery. A total of 600+ hours work was agreed to be dedicated to my internship agency.

> "Engage in a mentored experience. The TCBES Professional Intern will work directly with an agency mentor as well as the TCBES Internship Coordinator. The agency mentor is expected to guide the Professional Intern in all aspects,

> including project development, implementation, and hand-off. The agency mentor will also shepherd the Professional Intern through the agency on-boarding to ensure the Professional Intern is truly integrated into the agency culture."

At PACRC, I was proposed to have the opportunity to work with multiple mentors in different areas of expertise including Dr. Maria Haws, Sydney Gamiao, and Marni Rem-McGeachy. I committed to work under Marni Rem-McGeachy in the bivale hatchery and work closely with Sydney Gamiao for the Children's Learning Center project.

> "Knowledge of agency ecosystem. The scope should include a working understanding of the organization's culture and management, and when possible including project budgeting, securing funding sources, hiring, internal reporting, workflow, collaborations, and strategic planning."

To gain an overall picture of the work that PACRC conducts, I sought to shadow project managers in all research and production at the facility. The information gathered was projected to be used to create an informative binder deliverable to be used as an outreach tool for the Children's Learning Center.

> "Parameters of the agency's purview. The TCBES Professional interns will have to develop an aptitude of the policy regulations and laws relating to that agency's work or the academic subject matter."

I agreed to understand the best management practices and standard operating procedures PACRC follows to ensure I was working within their standards. I committed to attending seminars and achieve certificates to further my knowledge in safe and ethical protocol for handling marine life.

> "Advocacy or outreach experience. The TCBES Professional Intern will engage in some form of advocacy or outreach for the agency. As examples, activities could include support in organizing a public event, speaking at a public hearing, or speaking to the public in an outreach capacity."

At PACRC, I requested to work with my mentors in conducting community outreach to promote the Children's Learning Center space. Once we had accomplished bringing in an interested party, my goal was to take part in teaching classes and to create educational resources for after school programs.

*Timeline*

Table 1. This table displays various tasks I accomplished during the duration of my professional internship with the Pacific Aquaculture and Coastal Resources Center (PACRC). The X's represent the work I took part in throughout my TCBES professional internship. Time periods are listed at the top of the table.

| **Tasks** | **Summer 2019** *(May - July)* | **Fall 2019** *(August - November)* | **Winter 2019-2020** *(December - January 15)* | **Spring 2020** *(January 15 - May)* |
|---|---|---|---|---|
| Work in Bivalve Hatchery | **X** | **X** | | **X** |
| Transition pavilion space into Children's Learning Center (CLC) | | **X** | | **X** |
| Create 10-page informational binder resource for CLC outreach | | **X** | **X** | **X** |
| Shadow PACRC employees | **X** | **X** | | **X** |
| Create CLC educational resources | | **X** | **X** | **X** |
| Create SOP's for Hatchery | | | **X** | **X** |
| Learn live feeds methodologies | | | | **X** |
| Attend Dr. Maria Haws' aquaculture classes | | **X** | | **X** |
| Teach Thursday *Keiki* (Kids) Program, Manamoi O Hanakahi | | | | **X** |

## Approach

### *Strategies and Methods*

*Children's Learning Center*

To serve the community and educate the public on aquaculture practices, PACRC decided to design a Children's Learning Center. The area that was designated for the project was the approximately 14m x 7m pavilion space near the entrance of the PACRC facility. Before the start of the project, the space acted as storage and as a home for a working touch tank, an eastern oyster (*Crassostrea virginica*) and pearl oyster (*Pinctada margaritifera*) tank, and a University of Hawai‘i at Hilo Marine Option Program Coral Nursery tank.

To begin this assignment the pavilion space had to be transitioned into a clean and comfortable working space for PACRC to use as the Children's Learning Center. This process included the removal of unneeded equipment so that the walls and floor of the space could be cleaned. The remaining equipment was inspected and tested for structural integrity. I then created a pavilion schematic to envision the space as an educational resource (Figure 1). I measured the six potential tanks, the six tables, and the pump equipment. I scaled the measurements to an 8.5x11'' format and designed the final schematic of the Children's Learning Center layout. With the schematic as our guide, my co-worker and I used a Bobcat Skid-steer Loader to place our main feature tank in its designated location and we moved other equipment by hand as needed.

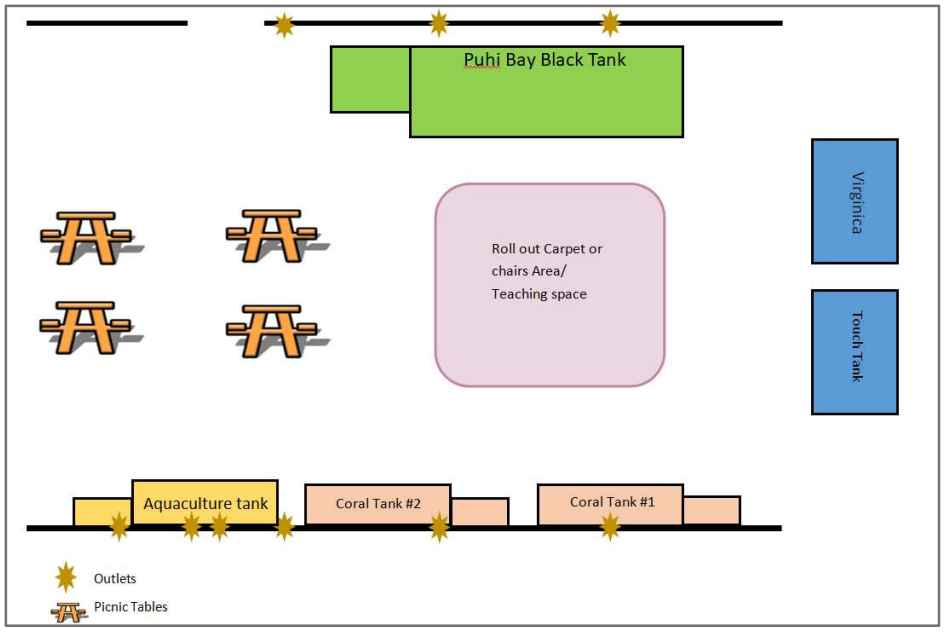

Fig. 1 Updated (as of May 3, 2020) schematic for the Children's Learning Center layout at the Pacific Aquaculture and Coastal Resource Center.

After the completion of the layout, the redesign of the tanks was conducted inhouse as well as contracted out. The contracted portion of the work involves the redesign of the largest feature, the Puhi Bay tank. It will be covered a lava rock-like design with added steps that reach the top of the tank. The contractor that has been brought on for this project started this redesign on April 29th, 2020. Once the feature tank is completed, our Marine Option Program coral nursery tank position will be slightly adjusted as well to finish the space.

Simultaneously, as the physical space transition process occurred, I created educational resources that instructors and PACRC employees will be able to use in the Children's Learning Center. These resources included informational posters, educational games, and take-home packets (Appendix B). I also created an approximately 10-page PACRC informational binder including information about the Children's Learning Center, production, and current research projects (Appendix C). This resource was created to be used in outreach meetings with community members and schools to promote our new Children's Learning Center space. To create this informational resource, I shadowed seven PACRC employees in efforts to gain a full

understanding of aquaculture and all of the projects and production at PACRC. When I shadowed and worked across the facility, I gained valuable hands-on experience and knowledge that not only helped me develop a successful Children's Learning Center plan, but also increased my knowledge in aquaculture practices.

When COVID-19 ended my hands-on labor prematurely, I started to collect dive photos of nearshore reef species. I compiled over 250 photos of 55 different species (Figure 2). These may not be professional photographs, but PACRC not having to worry about copyrights or photo credits will allow these photographs to be used freely for name tags, fish of the day activities, and any other idea the facility may imagine. I named each photo with their respective common and scientific names. These photos have been uploaded to a shared google drive, alongside all of the other educational resources, so that my mentors and other PACRC employees have access to them well into the future.


Fig. 2 A small example set of the dive photos I collected for PACRC's use. All of the photos collected were named with their respective common name and scientific names for easy identification and sorting. All the photos are uploaded to a shared google drive so that they can be accessed freely.

While I was creating the educational materials, Dr. Maria Haws, Sydney Gamiao, and I planned to begin working with the community and schools to gain insight as to what features will be most valuable in the Children's Learning Center space. Although this process is still in the works, my mentors and future interns will continue the correspondence with teachers at Ka ʻUmeke Kāʻeo, Keaukaha Elementary, and Kamehameha Schools to identify a target audience (likely upper level elementary through middle school) and to learn what the community wants from this educational space. I have created surveys, questionnaires, and draft emails to assist in this process (Appendix D). I also visited the Mokupāpapa Discovery Center for exhibit ideas that would benefit the completed area. Once the pavilion space is finished, and the teachers begin to schedule tours, future interns or employees will use the completed Children's Learning Center to teach class discussions.

*Bivalve Hatchery*

An important role of my TCBES professional internship was the 200+ hours I dedicated to working in PACRC's bivalve hatchery and nursery. This nursery produces pacific oysters (*Crassostrea gigas*) which are PACRC's only commercially sold animal. PACRC receives millions of *Crassostrea gigas* larvae from a partner hatchery Hawaiian Shellfish. PACRC then grows the oyster larvae through metamorphosis at which point the oyster transitions from a planktonic to a benthic individual referred to as seed. The seed is grown to a desired size in order to sell it to shellfish hatcheries on the West Coast. The PACRC facility produces both diploid and triploid versions of this species. This differentiation is important as diploid and triploid oysters have two different values in the market. Triploid oysters contain three sets of chromosomes while diploid oysters only contain two. Triploid oysters are sterile and do not need

to spend energy on reproduction, which in turn allows them to focus all of their energy on their growth. Although triploid oysters do have a chance of reverting back to diploid, they tend to have a greater value due to their ability to grow faster than diploid.

In the hatchery, PACRC follows strict biosecurity protocols to ensure the safety of the facilities staff, animals, and the surrounding environment. There is proper protective gear that employees are required to use at the facility to ensure their safety. At all times in the facility employees and guests must wear close-toed shoes as we are constantly moving equipment around and walking on loose gravel. When working with dangerous substances such as acid or other chemical reagents, employees are required to wear protective gear such as eyewear and gloves. Besides protecting the staff, there are also protocols to protect the animals at PACRC and the surrounding environment. To ensure that there is no contamination in the hatchery and nursery spaces, a typical workday involved completing "cleanest" tasks first and "dirtiest" tasks last. Larger oysters produce more waste which can cause their tanks to be dirtier and at a higher risk of contamination.

Following the biosecurity protocols, I usually started in the hatchery completing duties involved with the *Crassostrea gigas* seed. Almost every morning I cleaned out the bleach tub that contained equipment that was left to soak overnight. After that, there were various different daily tasks that I took part in throughout my professional internship to assist in oyster production. I cleaned screens and bins that are used in the nursery to culture the *Crassostrea gigas* oyster spat and seed. I prepared nutrients for growing microalgae that feed into the nursery systems. I screened oysters in the nursery in order to separate faster growing oysters from smaller runts in efforts to reduce their competition and contamination pressures. On a regular basis I organized

and cleaned dry equipment essential for production in the hatchery. Lastly, additional duties included assisting in occasional carpentry and plumbing work when needed.

After completing a combination of hatchery tanks, dependent on what was needed that particular day, I ventured outside the hatchery walls. I cleaned, drained, and switched pumps in the microalgae tanks that feed into our oyster systems. After that I cleaned, drained, and fed the eastern oysters (*Crassostrea virginica*) and pearl oysters (*Pinctada margaritifera*) in the pavilion space. When the cleaning and feeding were finished, I made sure that all the basic life support systems for oysters were hooked up to the tank. For survival, oysters need oxygen, food, and water as their basic life support systems. To ensure the tank had all of those requirements, I made sure the aerator was in the tank, the oysters were fed microalgae paste, and that the needed saltwater flow was running. Ending my days, I took care of our conditioning system that contains *Crassostrea gigas*, Kumamoto oysters *(Crassostera sikamea*), and native Hawaiian oyster species (*Dendostrea sandvincensis*). I drained the tank, scrubbed the oysters and equipment, and removed the dead oysters to prevent the spread of toxins or diseases. Before finishing the conditioning system, I also made sure that all tanks had their basic life support systems and that all tanks were set to their respective flows. Under my supervisor's direction, Marni Rem-McGeachy, I also created multiple Standard Operating Procedures to assist the student workers in the bivalve hatchery (Appendix A).

During my professional internship time spent in the hatchery, the most memorable and rewarding task that I participated in was the counting and sizing of oysters for a shipment that will eventually be transferred to Maui. In the near future, the oysters I counted will be released in the nearshore Maui waters in efforts by Maui Nui Marine Resource Council and the Waterkeeper Alliance to increase water quality through the oyster's natural filtration system. To be able to be

a part of that process is a task that I will never forget and will be thankful for as I move on from this program.

*Live Feeds*

Live food organisms are a valuable resource for aquaculture due to their ability to swim in the water column making them constantly available to fish and shellfish larvae. During my last semester of my TCBES professional internship, I was able to work in live feeds alongside my mentor Sydney Gamiao. At PACRC, we have rotifers (*Brachionus plicatilis*), copepods (*Parvocalanus crassirostris*), and brine shrimp (*Artemia franciscana*). At the start of the spring 2020 semester I was stationed to work with rotifers as their protocol was easiest to learn for beginner aquarists. Rotifers are microscopic aquatic animals found mainly in freshwater habitats. *Brachionus plicatilis* are tolerant to wide ranges of salinity and are the most common rotifer being raised as food for marine ornamental fish larvae in the aquaculture industry. One of the duties I carried out included monitoring and maintaining water parameters to ensure optimum water quality. To check water quality I measured the salinity, pH, and ammonia levels in our tanks. If any of the parameters were off, my job was to correct those differences by adding the appropriate amendment for each. If the pH was too low, I would add 5 g sodium bicarbonate for every 0.1 it needed to be raised. I would add 1 g ClorAm-X for every 10 mL of feed and every 0.1 mg/L the ammonia needed to be raised. In addition to monitoring water quality, I conducted weekly routines such as starting new rotifer tanks, dropping old rotifer tanks, calculating and setting feed amounts, calibrating machinery, organizing equipment, and cleaning equipment used for rotifers.

*Keiki in Aquaculture after school program*

The Keaukaha One Youth Development- RISE 21st Century After School Program, in collaboration with PACRC, hosted a free after school aquaculture program called Manamoi O Hanakahi. This program is for local children in grades 2nd-4th that included interactive learning in aquaponics and aquaculture of oysters, fish and *limu*. The class started on 27 February 2020 with five children registered for the program. Before the class started I created flyers to assist in advertising the opportunity to the community (Appendix E). I also prepared the pavilion space for lessons by ensuring safety parameters were considered. When the program began, I assisted Topaz Collins, a PACRC educator, with the teaching of aquaculture lectures and with hands on activities. During the classes we taught the children how to keep a scientific notebook, how to record important definitions, and introduced them to aquaponics and aquaculture systems. We took the students on a facilities tour and had them plant vegetables in the aquaponics systems, which they would then harvest in a few weeks. We also explored the children's creative side and had them perform gyotaku using a large frozen Tilapia. Unfortunately, after three weeks, COVID-19 ended the program early and I was unable to continue as an educator for the duration of the semester.

*Dr. Maria Haw's Aquaculture Class*

An amazing opportunity I got to take part in was attending Dr. Maria Haws aquaculture classes. Although not enrolled in the Fall Invertebrate and Algae Culture class or the spring Aquaculture of Fishes class, Dr. Haws allowed me to audit both of those classes. To participate in the Aquaculture of Fishes course, I completed the Institutional Animal Care and use committees (IACUC) oversight of vertebrate and animal care, working with fishes certificate.

This certificate is valid three years and will be required if I continue to work in an aquaculture setting in the future.

My position during the class was to assist Dr. Haws with lab setup and breakdown, taking class pictures, and anything else she needed, although my duties were scarce. This opportunity was truly a sole benefit to my knowledge in aquaculture practices, however, the knowledge accumulated during this class transferred well to my position at PACRC. For example, during class we covered how to properly ship fish. I learned the equipment needed for shipping, what parameters to keep in mind during shipping, and how to properly bag the fish. Dedicating time to educate myself on aquaculture practices as such, prompted me to overlap these new skills with my time working at the facility. After learning shipment protocol in class, I asked to be involved in an oyster shipment, allowing me to now have both fish and oyster shipping experience.

## Outcomes

### *Original Deliverables*

At the start of my TCBES professional internship in May 2019, my original purpose was to assist in the community-based Hilo Bay oyster raising project. However, my placement on that project did not occur, and I was asked to fill a gap needed in the bivalve hatchery on my first day of employment. Throughout the year of my professional internship, my hatchery labor deliverable was achieved with my 200+ hours dedicated to hatchery-oriented work.

However, about three months into my professional internship I wanted to expand my opportunity outside of the hatchery. I asked my mentor Sydney Gamiao if there were any other projects that I could assist on, and in August 2019, we decided that I should begin the planning of Children's Learning Center. One of my original deliverables for this project was to complete

the renovation of the pavilion and set up the new tanks. The other deliverable was to create educational resources, participate in outreach for the space, and to start teaching school groups in the completed Children's Learning Center. Due to timing issues and the reliance of outside companies for tank set up, the pavilions transition was not able to be completed during the time I was an intern. As there was a pause on the transition attempt, the outreach efforts also were postponed leaving many of my desired deliverables incomplete.

Although not every part of the transition we sought out to do was completed, this push of me wanting to participate on another project got the renovation process started for the pavilion space. Alongside my mentors I organized pavilion cleanup days, moved tanks into their proper position, created outreach tools to distribute to local schools, created educational resources for the completed space, and completed other various tasks to jump start the transition process. Throughout doing those tasks, we realized what was really needed to take on this large project and were able to adjusts our expectations and timeline accordingly. This project may be far from completed, but this project will continue past my internship duration and will become a valuable resource not only for PACRC, but also the local community once it is achieved.

### *Additional Achievements Outside of the Original Proposed Deliverables*

During my TCBES professional internship, I had the opportunity to achieve and participate in many tasks above and beyond my original proposed deliverables. In addition to working in the oyster hatchery, I was able to spend time working in live feeds and attend professional aquaculture lectures. Knowing how to maintain live foods for aquaculture systems is essential, as well as all of the techniques and methods taught in Dr. Maria Haw's aquaculture classes. Alongside of those opportunities, I was also able to teach children aquaculture and

aquaponics through the Manamoi O Hanakahi program. The skills I gained walking out of this experience will benefit me greatly in my future conservation career.

In regards to the Children's Learning Center educational resources, I achieved more than I was proposed to do at the beginning of my professional internship. My original deliverable was only to make the informative binder and a handful of posters. I surpassed this minimum requirement by also creating a variety of games, flyers, draft emails, and surveys for PACRC's Children's Learning Center transition. I was also able to compile the extensive collection of nearshore reef species photography that can be used for potential lessons and advertisement purposes. As I move on from this organization, these resources will continue to be used far in the future making me proud that I was able to make a valuable contribution to the organization.

Another exciting bonus opportunity I got to take part in during my time at PACRC was the collection of oysters for genetic research. Outside of my TCBES professional internship, I am a Pacific Island Ocean Observing System (PacIOOS) technician for two water quality buoys in the nearshore waters around Hawai‘i island. While performing regular maintenance on the buoys, co-workers and I were able to carefully remove and collect over a dozen oysters off the buoys for PACRC's use (under Special Activity Permit No.2020-71). With those collections, I was able to use my resources from my job to benefit the research PACRC and University of Hawai‘i at Hilo are conducting.

## Discussion

### *Benefits to the Professional Interns Organization*

This TCBES professional internship benefited the mentor organization with approximately 600 labor hours assisting in oyster seed production, creating and facilitating the

Children's Learning Center space, and aiding with other various tasks or projects. This labor allowed the facility to achieve a jump start on the pavilion's transition into an educational resource, therefore, will allow the space to be used sooner than the proposed deadline prior to my employment. Although PACRC has fostered many research TCBES students, my professional internship experience opened up the door for future internship opportunities for graduate students as PACRC's relationship with the Tropical Conservation Biology and Environmental Science Professional Internship Master's track was established.

***Broader Impacts of PACRC Aquaculture***

People that reside in Hawai‘i consume double the amount of seafood per capita than the rest of the nation, yet the State of Hawai‘i non-sustainably imports the majority of its seafood creating a large carbon footprint (Loke et al 2012). PACRC's mission is to advance long-term sustainable use and conservation of coastal areas worldwide through aquaculture and resource management. With proper knowledge and the practice of farm raising marine species, we can try to eliminate the high demand for wild caught and imported products for consumption. This in turn will protect our oceans by taking pressures off the collection of wild populations and minimize the negative effects of overfishing we have created around the world.

Besides consumption, there are many different possible reasons why certain species are being farm raised such as their ecological value. As mentioned previously, oysters are filter feeders that pump water through their gills to trap food, nutrients, sediment, and chemical contaminants. This process helps regulate water quality issues and is a natural process we should be taking advantage of. As for PACRC, more than 10,000 triploid non-native and haploid native oysters produced at our facility have been out-planted in the nearshore waters of O‘ahu and

Maui. These release spots include the Joint Base Pearl Harbor-Hickam, the Marine Corps Base at Kāneʻohe Bay, the Hawaiʻi Yacht Club, the Waikiki Yacht Club in the Ala Wai Harbor, and most recently at Honolulu Community College's Marine Education and Training Center at Sand Island. This utilization of bivalves for mitigating water quality issues also allows for the restoration of native Hawaiian oyster species.

Although a large amount of aquaculture is food fish or shellfish production for consumption, ornamental fish can also be cultured. Ornamental fish can be overfished due to their high demand from hobbyists for trade purposes causing negative health effects on nearshore reefs. PACRC currently has a coral reef fish breeding program containing approximately 10 endemic Hawaiian species, some of which hold cultural importance. The goal for this program is to have the fish spawn at the facility and create viable offspring that can then be sold to fish collectors. If PACRC is able to successfully produce and sell ornamental fish, this can offer hobbyists and commercial collectors an alternative which would then take pressure off our nearshore reefs and create new jobs locally.

Lastly, one of the most important impacts in regards to my personal internship process will be the completed result of the Children's Learning Center. This space will educate the keiki of our future by providing them a safe and comfortable space to learn and expand their knowledge of sustainability, aquaculture practices, and native species and ecosystems found around the Hawaiian Islands.

**Conclusion**

Overall, this Tropical Conservation Biology and Environmental Science Professional Internship Master's Degree Program shaped my future career path. This program introduced me

to opportunities I otherwise would have not been exposed to without the program. In regards to my aquaculture professional internship experience, I executed crucial animal husbandry skills, gained outreach and education experience, and above all expanded my knowledge and hands-on skill set in aquaculture practices. On the academic side, I was able to network and make connections with many leaders in the conservation field. During the professional internship program, I also learned how to be my own advocate and to keep my internship and career search options open in order to achieve the highest success during the process of this program.

Being raised and completing my undergraduate degree in Pennsylvania, my background in marine science and environmental studies stems from ecosystems found along the east coast of the United States. My undergraduate marine science hands-on experience was obtained in environments such as salt marshes, estuaries, and mudflats. Most of my environmental studies undergraduate field research was conducted in streams and deciduous forest environments. Moving from the east coast to the island of Hawai‘i for this professional internship program, I have been immersed in new environments such as tropical forests, lava flows, tropical coral reefs, and more. This exposure surpassed anything I could have learned from a textbook, and the engagement in field research with these new environments has lead me to be a well-rounded conservationist that can tackle any field environment I will be faced with.

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## Appendices

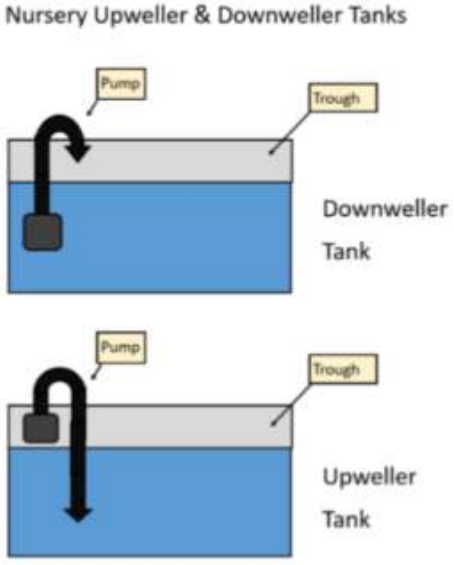
*Appendix A, Standard Operating Procedure Example*

**Up weller tanks**

Life support systems for oysters: All animals need saltwater, algae, and air. All nursery tanks, conditioning system tanks, and pumps require the life support systems.

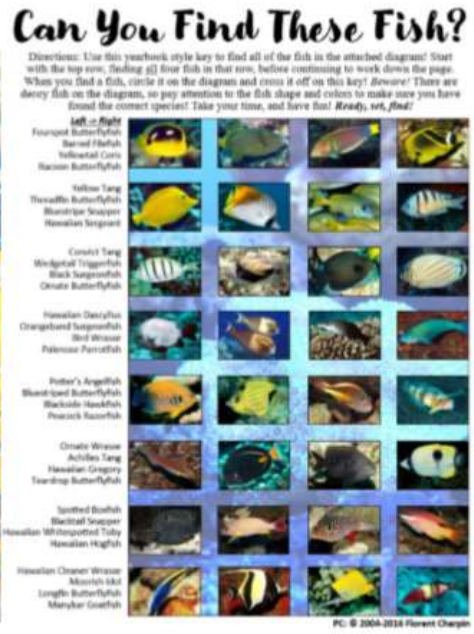
Prior to dropping up weller tank:

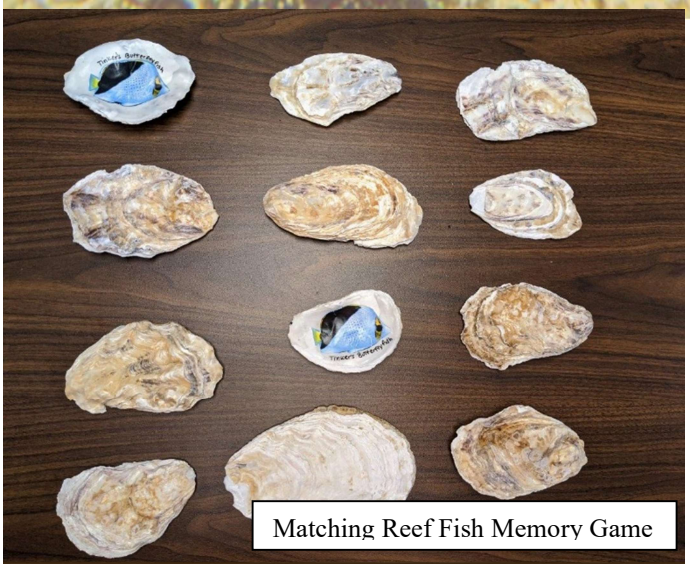
1. Unplug pump
2. Turn off saltwater and algae
3. Pull the standpipe and lay standpipe across the drain (to encourage slow drain which is important so the 200 micron screen bins do not tare)
4. Unscrew the union for the trough standpipe and let tank fully drain
5. Spray down entire tank including inside and out with freshwater hose making sure to move animals across screen (more waste as animals get older so important to get all waste out)
6. Once completed, screw in union for trough standpipe but do not put standpipe in the trough yet
7. Place tank standpipe in drain
8. Blast saltwater and algae to get the tank as dark as possible for good background algae density
9. Watch water level of tank is essential, as the water level gets to the bin, between the bin bottom and the port it is important to tap down any animals adhering to the surface tension so spread out and tap down before they get to the port. If there comes a point if you are scrambling to tap them down, turn off water and algae completely.
10. Once tank is completely filled, place trough standpipe into its fitting
11. Set algae and saltwater flows
12. Turn on pump



*Appendix B, Informational Posters and Games*



Matching Reef Fish Memory Game

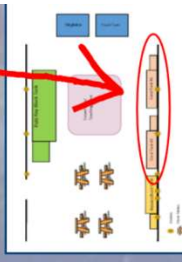
*Appendix C, Informational Binder Pages*

## Pacific Aquaculture & Coastal Resource Center (PACRC)

PACRC's mission is to advance long-term sustainable use and conservation of coastal areas worldwide through aquaculture and resource management. The center promotes excellence and innovation in interdisciplinary scientific research, public policy initiatives, outreach activities, and education. Our long-term goals are to provide an infrastructure needed for world-class aquaculture and marine science programs at UH Hilo, support commercial aquaculture, fisheries and conservation in East Hawai'i and globally.

The Pacific Aquaculture and Coastal Resources Center (PACRC) is a coastal site in Keaukaha on the Big Island adjacent to the Port of Hilo. Once an old wastewater treatment plant, the site now focuses on marine ornamental and foodfish culture and the cultivation of oysters. The new PACRC facilities, in combination with the UH Hilo Marine Science Building, greatly enhances the international reputation as a premier location for education and research in marine sciences, aquaculture and coastal resources.

## MOP Coral Program Tanks

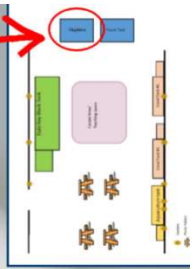


Tank's Goals: This coral conservation project is highly student oriented. This tank is used to teach the Marine Option Program Students coral husbandry. The goal is to successfully grow corals and replant the coral fragments on damaged reefs on Hawai'i Island.

What you'll see: This tank holds rice, lobe, and oscillated corals. The corals in this tank were collected from eggs via live corals or from fragments collected from ship wreckage off of Hawai'i Island.

Project heads Scott and Michelle

## Eastern Oyster Tank (*Crassostrea virginica*)



Tank's Goals: Educate students about water remediation with oysters. Since this tank will be in the Children's Learning Center, it will allow keiki the opportunity to touch and feel a live oyster.

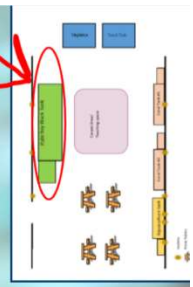
What you'll see: You will see various sizes of Eastern Oysters collected from Pearl Harbor in Oahu. Eastern Oysters have smooth edges and are oval in shape. You will also find a hand full of Pearl Oysters *(Pinctada margaritifera)* that have a circular appearance and have a tendency to latch on to one another.

PC: Maya Munstermann

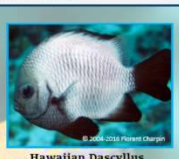
## Puhi Bay Tank

Tanks Goals: Introduce common coral reef fish to PACRC visitors that may have never experienced them firsthand in the wild. This tank will provide PACRC the ability to teach students which species they may encounter if they choose to go snorkeling or fishing in the nearshore Hawaiian waters.

What you'll see: A variety of species that you would find in nearshore waters around the Hawaiian Islands. Examples of projected tank species are provided below.



**Achilles Tang**
*Acanthurus achilles*



**Hawaiian Dascyllus**
*Dascyllus albisella*

**Potter's Angelfish**
*Centropyge potteri*

**Yellowtail Coris**
*Coris gaimard*

**Yellow Tang**
*Zebrasoma flavescens*

**Convict Tang**
*Acanthurus triostegus*

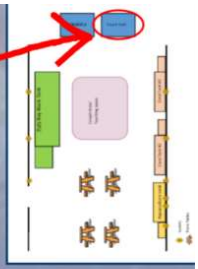
**Bluestriped Butterflyfish**
*Chaetodon fremblii*

**Bird Wrasse**
*Gomphosus varius*

**Raccoon Butterflyfish**
*Chaetodon lunula*

## Dave's Touch Tank

Tank's Goals: This tank will be filled with a variety of different species that the students can view and interact with. From this tank students will learn different animal behavior traits, what species feel like, and how species interact with each other.



What you'll see: It could depend on the time of year that you visit but the tank currently has Aholehole, a Hawaiian Day Octopus, a Hawaiian spiny lobster, Banded Coral Shrimp, and Mozambique tilapia.

Employee Maya Munstermann checks algae bag system

## PACRC's projects, research, and production conducted outside the children's learning space

Employee Marcellus works in the larval rearing facility

PC: Maya Munstermann

## How do we feed the organisms and animals at PACRC?

Microalgae is the primary source of nutrition for our oysters, copepods, rotifers, and Artemia. Large scale production consists of a continuous algae production bag system that produces approximately 4,000 liters of algae water per day. The copepods and rotifers are fed the algae and are then used as a food source for other animals such as the marine ornamental fish.

*Algae Inoculations*

Our stock cultures consist of multiple species that make up our algae bank. All of the algae produced starts off as a stock culture and are turned into working cultures called Mother-Daughters. These working cultures make all of the algae on PACRC campus. They start as a 125mL daughter of algae media, macro ingredients, trace manganese, and salt water.

Then, these "daughters" are inoculated into the "mothers" and are allowed a time of 2-4 days for the cells to multiply. This inoculation involves neutralizing and sterilizing the containers with bleach or an autoclave, then adding nutrients and vitamins (F media, standard media) to the mixture. The algae is then added and given time to multiply and utilize the nutrients. Following, these 1-liter mothers are then inoculated into 15 liter gallon containers that allow for even greater space for the algae cells to multiply.

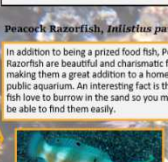
Where do the 15 liters go? They then go into the outside bag system which is our continuous harvesting system. For the bivalve hatchery and the conditioning system, the algae flows into mini reservoirs (the black trash cans) and once it hits the volume the float valve is set at, it is sucked to big black holding containers. These containers allow for a huge amount of room for the algae to grow and multiply. From the big black containers, half is fed to the hatchery and half to the conditioning system. The hatchery and conditioning system are where our oysters can be found.

## Coral Reef Fish Breeding Program

There is a coral reef fish breeding program at PACRC that includes approximately 10 endemic and/or culturally important Hawaiian species. The programs goal is to have the fish spawn and create offspring that can be sold to collectors. These captive fish cannot be returned to the wild, so the idea is that selling to collectors will reduce their pressure of gathering from wild populations on nearshore reefs.

**Peacock Razorfish, *Inlistius pavo, laenthi***

In addition to being a prized food fish, Peacock Razorfish are beautiful and charismatic fish making them a great addition to a home or public aquarium. An interesting fact is that these fish love to burrow in the sand so you may not be able to find them easily.



Tinker's butterflyfish are valuable aquarium exports making them now a rare sight at sport-diving depths. This fish prefers waters ≥45 m (150 ft), but can occasionally be found at depths ~30 m (100 ft). These fish are relatively easy to catch and have been observed hand feeding from divers.

Ricky Tabandera

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**Tinker's Butterflyfish, *Chaetodon tinkeri***

Hawaiian Dascyllus are among the more frequently collected species for ornamental purposes so they tend to be cheaper in price. Between 1976 and 2003, roughly 49,000 fish were caught bringing in $48,000 for the state of Hawai'i.

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Tim Grabowski

Flame wrasse are great aquarium fish, but with competitive nature, one male per tank is needed. They may start off being very inactive when first introduced to the tank, but will eventually acclimate. These fish can be found at depths over 30 m (100 ft) and are a common find for divers off of O'ahu.

**Flame Wrasse, *Cirrhilabrus jordani***

**Hawaiian Dascyllus, *Dascyllus albisella*, 'ale'ilo'i**

Achilles Tangs are common along rocky shores with moderate wave action. Small species of tangs are great aquarium fish, however, they are aggressive to their own kind leaving it best to keep them singly.

Hawaiian longfin anthias are endemic to the Hawaiian Islands. They are found at depths from 25-70 m (82-230 ft), making collection more difficult for this species than for other fish.

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**Hawaiian Longfin Anthias, *Pseudanthias hawaiiensis***

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**Achilles Tang, *Acanthurus achilles*, pāku'iku'i**

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Potter's Angelfish are the only truly common angelfish found on Hawaiian reefs. This fish ranks as one of the top ornamental fish exported from Hawaii reefs and is a good representative of a difficult to rear species in captivity.

**Potter's Angelfish, *Centropyge potteri***

## Bivalve Hatchery

Hatchery Goals: Increase the prevalence of shellfish farming in Hawai'i while supporting oyster farms locally and on the West Coast. Here we have a student workforce training program that provides students with opportunities to experience oyster production for research and commercial purposes. The only commercially produced oyster in this hatchery is the Pacific Oyster (*Crassostrea gigas*).

Depending on the needs of the facility being sold to, the oysters are usually sold as eyed larvae size or "spat" size. They come into our facility as seed and we grow them until they form an eye spot and set which is a process that takes ~4 weeks. If the facility wants them larger, we can take an approximate extra month to grow them to a spat size of ~1.4mm to ~6mm.

PC: Maya Munstermann

## Native Oyster Project

The goal for this project is to raise and propagate out native oyster species and pacific oysters (*Crassostrea gigas*) at PACRC for their release in nine different locations around O'ahu and Kaua'i. As filter feeders, oysters are able to pump water through their gills trapping food, nutrients, sediment, and chemical contaminants. This natural process could mitigate water quality issues helping clean our nearshore Hawaiian waters and elsewhere worldwide. This restoration project involves the community, and keiki are responsible for monitoring and maintaining the oyster cages once they are set. The Native Oyster Project is in partnership with WaterKeepers Alliance, O'ahu.

Photos: Planting ceremony for native Hawaiian oysters species in O'ahu.
Date: October 23, 2019.

## Food Fish Production

Project Goals: Build a indoor broodstock facility for raising food fish fingerlings to provide to the public and Hawaiian fishponds. This project will be moved to our new renovated fish hatchery when completed. Keeping this project in a temperature controlled room allows for species to be conditioned for spawning that otherwise would not be able to produce eggs at lower temperatures outside. Being able to provide fish fingerlings opens up opportunities for more aquaculture fish in the state.

What you'll see: Moi, Nabeta, and Āholehole. These species were chosen because they are a highly prized foodfish, although they are sometimes difficult to rear. In particular, Nabeta are a burrowing fish, which can present challenges for rearing.

Bryan Harry/National Park Service

Moi

Nabeta

Bryan Harry/National Park Service

Āholehole

*Appendix D, Survey example*

# Pacific Aquaculture and Coastal Resources Center's Educational Center Survey

The Pacific Aquaculture and Coastal Resources Center (PACRC) is a coastal site in Keaukaha on the island of Hawai'i adjacent to the Port of Hilo. Two of the facility's long-term goals are to provide the infrastructure for world-class aquaculture and marine science programs at UH Hilo and to support commercial aquaculture, fisheries, and conservation in East Hawai'i and around the globe. PACRC promotes excellence and innovation in interdisciplinary scientific research, public policy initiatives, outreach activities, and education.

At PACRC, the initiative has been taken to create a children's Learning Center that will promote community engagement and education. The Learning Center will accommodate school trips and after school programs for elementary through middle school students. The open outdoor pavilion space near the entrance of PACRC's facility, measuring approximately 14m (46ft) by 7.6m (25ft), is the space dedicated for this project. The plans for this space are being developed and ideas include a variety of different tanks, a possible seating area, and educational resources such as posters and games.

As we are currently in the renovation process, we would like to take this time to reach out to educators in efforts to collect information and advice on what to include in this space. The confidential responses provided to the questions below will be considered when shaping the space into an educational resource center. Please answer the four questions on the following pages with your honest opinions and ideas including as much detail as possible. We look forward to the completion of this project and thank you for your assistance with this process.

Name: _____

Institution of employment:_____

Question 1: Of the classes you are currently teaching, what classes can you picture benefiting from our children's learning center? Within these classes, what are your top learning outcomes? How could our space help you achieve those outcomes?

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Question 2: What age groups do you see benefiting the most from a space like this? What age specific ideas would you have on materials to include in the space?

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Question 3: If you had access to this space, how often would you like to utilize it? Would it be a consistent lab site to visit or would it be treated more as a field trip site? Are there certain aspects that can be included in the space that would drive you to utilize it more (i.e. a touch tank, certain species/projects, etc)?

---

Question : If we were to give this space a name, what name do you think would best support the centers goals and best convey our intentions to the community?

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*Appendix E, Flyer Example*

# Manamoi O Hanakahi

The Keaukaha One Youth Development- RISE 21st Century After school Program in collaboration with the Pacific Aquaculture and Coastal Resources Center are recruiting keiki in grades 2-4 for a free after school aquaculture program. This semester long program will include hands on learning in aquaponics and aquaculture of oysters, fish and limu. This class is projected to start at the end of February and is limited to the first twelve keiki registered. Contact Topaz Collins for more information at topazcollins@gmail.com

*When: Thursdays 2:30pm to 4:30pm*
*Where: Pacific Aquaculture &*
*Coastal Resources Center*
*1079 Kalanianaole Ave, Hilo, HI*

KEAUKAHA ONE YOUTH DEVELOPMENT