### Culminating Activity

**Key Concepts**

- Environmental impacts on both aquatic and terrestrial environments influence the abundance of species and a species' competitive advantage.
- Introduced species often introduce an introduced species chain.
- Water quality and pond health are a negative factor on aquatic organisms in ponds.
- Excessive nutrients and fertilizers and

**Concepts**

- Environmental conditions
- Consider the niche of the invasive species
- Consider the aquatic ecosystems
- Organisms: number of introduced species per

**Assessment**

- Materials and equipment to be used.
- Hypotheses, including the procedure.
- Hypotheses, including their plans to test.
- Summarize their plans to test.
- Develop hypotheses about the diversity.

**Focus Questions**

- What will measure of Eutrophication and the relative abundance of species in the pond reveal about the diversity of species? Develop a hypothesis about the diversity of species? Develop a hypothesis about the diversity of species? Develop a hypothesis about the diversity of species? Develop a hypothesis about the diversity of species?

**Focus Questions and Activities**

- Hypotheses to test: Hypotheses to test: Hypotheses to test: Hypotheses to test:
- Design and construct: Design and construct: Design and construct: Design and construct:
- Develop and clarify: Develop and clarify: Develop and clarify: Develop and clarify:

**Activities**: Melamine Olga: Environmental conditions

- Hypothesis: Melamine Olga: Environmental conditions
- Hypothesis: Melamine Olga: Environmental conditions

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Review criteria for assessing students' presentations and have them work with you to develop a rubric (see sample rubric provided).

### Sample Rubric for Culminating Activity

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<tbody>
<tr>
<td><strong>Science: Doing Scientific Inquiry</strong></td>
<td>Presentation provides clear explanation of data, methods, and conclusions; provides an exceptional analysis of alternative explanations or conclusions.</td>
<td>Presentation provides clear explanation of data, methods, and conclusions; provides a good analysis of alternative explanations or conclusions.</td>
<td>Presentation lacks focus; some information is clearly presented, but needs more organization.</td>
<td>Presentation is unclear; needs more organization and information to convey data collected and conclusions drawn.</td>
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<tr>
<td>Points</td>
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<tr>
<td><strong>Science: Malama I ka ‘Āina</strong></td>
<td>Presentation clearly analyzes consequences of human changes to the system. Solutions proposed to the negative consequences show evidence of critical analysis.</td>
<td>Presentation clearly analyzes consequences of human changes to the system and proposes thoughtful solutions to the negative consequences.</td>
<td>Presentation analyzes consequences of human changes to the system, but does not propose adequate solutions.</td>
<td>Presentation does not show consequences of human changes to the system or propose solutions.</td>
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<td>Points</td>
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<tr>
<td><strong>Visual Aids</strong></td>
<td>Visual aids enhance understanding of content; have high visual appeal.</td>
<td>Visual aids support content and are appropriate in quality.</td>
<td>Visual aids are minimal and not entirely effective.</td>
<td>Visual aids are incomplete or not appropriate.</td>
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<td>Points</td>
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I NOTICED:
Discovering Density and Diversity

- What will measures of species' density and diversity reveal about the fishpond ecosystem?

Hawai‘i DOE Content Standard

Science: Doing Scientific Inquiry
- Students demonstrate the skills necessary to engage in scientific inquiry.

Grades 9 - 12 Performance Indicators

- Ask clarifying questions and develop hypotheses that drive the investigations.
- Describe and carry out a plan to test the hypotheses. Include procedures, materials and equipment needed.

Key Concept

Determining the diversity (variety) and density (number of individuals per unit area) provides information about the structure of an ecosystem and the relative abundance of native versus introduced organisms.

Prerequisite

Investigating Interrelationships, Unit 2

Activity at a Glance

Students practice sampling methods that they will use in a fishpond field study and develop hypotheses about the density of limu species they will find at the pond.

Skills

observing, measuring, analyzing, predicting

Assessment

Students:
- Develop hypotheses about the density and diversity of species they might find at the fishpond and describe what these measures will reveal about the ecosystem.
- Summarize their plans to test hypotheses, including the procedures, materials and equipment to be used.

Time

1 - 2 class periods
Vocabulary

transect – a line across a given area, along which information is collected
quadrat – a sampling plot for use in studying plant or animal life
pa'ipai – to strike, as in striking the water surface to scare fish into a net
density – the number of individuals per unit area
diversity – variety
relative abundance – the proportion of objects in a group, expressed as a percentage of a
particular type
scientific method – a process to generate new knowledge that involves asking a question,
  stating a hypothesis, planning and conducting an investigation to test the hypothesis,
gathering data, analyzing data, communicating findings, and defending or revising
conclusions based on evidence

Materials

Provided:
• student activity sheet
• pond life cards (in Appendices)

Needed:
• rope (cut into two 10-meter lengths)
• permanent marker
• 8 meters of 1-inch diameter plastic pipe cut into eight one-meter lengths*
• 8 1-inch diameter plastic pipe “elbow” joints
• box of different colored toothpicks

*These materials are for constructing square meter quadrats to be used in a field study. An
alternative is to use a different method of study that requires only two meter sticks.

Advance Preparation

Copy an activity sheet for each student and copy and laminate the pond life cards provided
in the Appendices.

Note: You may want to have students help with the preparation of equipment for the field
study. To prepare the two transects, cut the rope into two 10-meter lengths. Mark the ropes
with a permanent marker at one-meter intervals. Prepare two quadrats to use with the
transects. Cut a 1-inch diameter plastic pipe into eight one-meter lengths. Attach a 1-inch
diameter pipe elbow to each length of pipe to make two one-meter squares. Drill a few holes
in the pipes of one quadrat so that it will sink (and not float away) when used in the shallow
water on the field trip. Note, if making the quadrats is problematic, use the meter stick
method instead. (See Background.)
Background

To monitor the diversity of species in the environment and the density of individual species, researchers have devised various ways to estimate plant and animal populations. Taking a total count of species is only possible with large or conspicuous organisms or with those that aggregate into colonies in a relatively small study area. Since taking a total count is not usually feasible, researchers use various methods to estimate the populations of species in a study area. The number transects used and plots or areas sampled is determined by the size of the area to be sampled.

Quadrat sampling – counting organisms in plots along transects of appropriate size and number to get an estimate of density in the area sampled. This method is described in this activity with suggestions for students to practice sampling before going to the fishpond.

Line transect with meter stick – counting organisms that are visible in the spaces between the edges of a meter stick, along transect lines. The researcher holds a meter stick while walking along the transect line and counting species that are seen in the space between the edges of the stick. The number of meters sampled along each transect line depends on the size of the area being studied.

Line transect with threshing rake – (for sampling in an aquatic environment) counting organisms collected with a long handled threshing rake. A two-meter circle is visualized and three rake grabs are made within each third of the circle. The rake is lowered to the sediment, twisted 180 degrees and lifted out of the water. All plants on the rake head are counted and identified to species. Transects are placed perpendicular to the shoreline at regular intervals (depending on the size of the pond). They begin and end at either the shore or an emergent plant bed. Sites are sampled at intervals along each transect.

Teaching Suggestions

1. Explain that students will be visiting a fishpond ecosystem to find out more about the organisms that live in a pond and how human activities are affecting water quality and pond life. Review what students learned in the prerequisite activity, Investigating Interrelationships in Unit 2.

2. Discuss methods for studying or sampling animals at the pond. How could students find out the relative abundance (the percentage of total numbers) of a species at the fishpond? Define “density” – the number of individuals in an area. How could they learn about the density of species and diversity or variety of fish at the fishpond?

- pa‘ipa‘i method – to catch fish and other organisms in the pond with large surround nets that have weights on the bottom and floats on the top. Pond coordinators will secure the nets and students will form a chain, an arm’s length apart, and move like a huge broom across the pond toward the net. They will pa‘ipa‘i (strike) the water surface with fronds or hands and scare the fish into the net. The animals caught will be a sample of the diversity of species in the pond. The fish will be placed in buckets for students to identify and study.

3. Ask students what some of the shortcomings of this method might be for studying the fish populations in the pond. (The smaller fish will fit through the holes in the net and some species of fish are more wary of nets and elusive, so this method will provide only a rough estimate of the density and diversity of fish in the pond.)
4. Discuss why scientists make these measurements. Why is it useful to have information about the diversity or density of species in an area? (The effect of a population in an ecosystem depends not only on what kind of organism is involved but also on how many. For example, one large predator, such as an ulua, in a 100-acre fishpond would have little effect on the ultimate yield of fish, but 1000 ulua per 100 acres would be great cause for concern.)

5. Ask students how they could find out about the relative abundance of plants at the pond (in the water and along the shore). Since it's too difficult to count all of the plants, how do we sample the plants and estimate density? Discuss methods described in the Background using transects and quadrats or meter sticks.

6. Discuss why we might want to study the plant populations in the fishpond. Review the information on the invasive limu pond life cards with students and discuss the problems posed by these invaders. (Refer to the Background in the prerequisite activity, Investigating Interrelationships, Unit 2 for additional information.)

7. Have students practice sampling using the quadrat method (or the meter stick) along the transects.

Procedure
• Lay the transect lines out in a cleared area (in the classroom or hallway or on the school grounds). Sprinkle various amounts of different colored toothpicks randomly in the area. Each color could represent a different species of limu (algae).
• Place a quadrat (or a meter stick) next to each transect line at one end of it.
• Form two groups, one to work on each transect line. Ask students to count and record the number of each colored toothpick they see within each square meter quadrat (or between the edges of each meter stick). Then have them estimate the percent of area covered by each colored toothpick in the quadrat and record that data. It helps to mentally divide the quadrat into quarters, and visually estimate how much space a species is covering.
• Move the quadrats (or meter sticks) two meters farther along the transects and repeat the sampling procedures with different students counting or estimating cover and recording. Repeat the procedure until everyone has had a chance to participate.

8. For each transect line, ask students to calculate the density for each species of toothpick "limu." The area studied would be the total number of square meters sampled (or meters sampled for the meter stick method).

\[
\text{Density} = \frac{\# \text{ of individuals}}{\text{area}} \quad \text{or} \quad \frac{\text{total \% \ covered \ in \ quadrats}}{\text{area}}
\]

Which "limu" had the highest density (# of individuals per square meter)? Which limu had the highest density when the percentage of area covered was estimated? Which method was more accurate? Which method would be most practical in the field? (Since it is difficult to count individual species of limu or plant species along the shore, students will probably want to estimate the percentage of cover for each species they record in a quadrat.)
9. Distribute the student activity sheet and challenge students to develop hypotheses about the diversity of limu species they will find at the fishpond. Use the pond life cards as a resource and encourage students to research additional information (see Resources listed at the end of this activity). Ask students to select one native and one introduced limu species and develop hypotheses about the density of each species in the pond.

10. Ask students to describe a plan to test their hypotheses. Their plans should include procedures, materials and equipment needed. Have them include a description of what these measures will reveal about the ecosystem.

Extensions/Adaptations

- Have students practice the quadrat sampling method, estimating percentage of cover for plants on the school grounds. Another way to practice estimating percentage of cover is to estimate the area of sky that is not covered by clouds.

- Ask students to select one of the species described in the pond life cards and conduct research to learn more about the role of the species in the fishpond ecosystem.

- Invite a scientist from the botany or zoology department of the local college to visit your class and discuss research methods and describe the skills and education required for a career in these fields.

- Have students make equipment for their fishpond field study. They can create viewing tubes to help them see the bottom of the pond when they are studying limu. Cut the bottom out of a 1/2- or 1-gallon shoyu jug. Insert a thin Plexiglass sheet cut to the size of the bottom opening. Seal it with silicone around the edges. Enlarge the top slightly to allow for easier viewing by cutting part of the jug away. Students could also make plankton nets. For detailed instructions on making a plankton net, see http://www.njnmsc.org/Education/List%20Lessons/List%20Lesson-Plankton.htm

Resources

Northwest Center for Research on Women. Rural Girls in Science - Meeting the Challenge Through a Comprehensive Approach. (Copyright © University of Washington, Seattle, WA. Funded by the National Science Foundation Project HRD-94500053) <nwcrow@u.washington.edu> http://depts.washington.edu/rural/RURAL/design/portfolio.html (This site offers worksheets on the scientific method.)

Offwell Woodland and Wildlife Trust. <offwell1@aol.com> http://www.offwell.free-online.co.uk/biol_sampl_cont.htm (This site provides information on ecological sampling methods.)

University of Hawai’i at Mānoa Botany Department. Hawaiian Reef Algae. (Copyright © Gerald D. Carr) <gerry@hawaii.edu> http://www.botany.hawaii.edu/reefalgae/

Wiley, John & Sons, Inc. 1995. Biology Fundamentals. <rwingerden@smjusd.sbceee.kqw.ca.us> http://webpages.charter.net/kwingerden/erhe/aquarium/processs.htm#OrganizingData. (This site has an excellent description of each step in the scientific method.)
Clearly state the question that your study is designed to answer and the hypothesis that you have developed.

**Research Question**

**Hypothesis**

**Method**
Describe the method to be used to test your hypothesis. Include the procedure, materials and equipment you will use.

**Results**
After your field trip, organize and summarize the data that you collected with your team. Use a separate sheet to present this information in graph or table format.

**Conclusions**
Write a conclusion based on your results. Include answers to the following questions in your conclusion: What is the answer to your research question? Did your results support your hypothesis? If not, what alternative hypothesis might explain your results? Based on your results, what recommendations would you make for caring for the fishpond?
Mālama Ola
To Support Life
Huaka‘i (Field Trip) 2

- How are human activities affecting water quality and the fishpond environment?

Hawai‘i DOE Content Standards

Science: Doing Scientific Inquiry
- Students demonstrate the skills necessary to engage in scientific inquiry.

Science: Mālama I Ka ‘Āina
- Students make decisions needed to sustain life on Earth now and for future generations by considering the limited resources and fragile environmental conditions.

Grades 9 - 12 Performance Indicators

- Use technology and mathematics to collect, organize, and display data appropriately and clearly. Analyze and validate the data.
- Examine the evidence and construct logical and reasonable explanations, conclusions, and models supported by accurate data.
- Analyze the consequences of change on the entire system and propose solutions to negative consequences.

The following indicators apply to the culminating activity. (See Unit at a Glance.)

- Share the explanation and conclusion with peers or outside audience. Provide a reasonable explanation to inquiries/questions from the audience based on sound scientific methods and concepts.
- Identify and explain the merits and/or demerits of alternative explanations, conclusions, and models.
- Revise explanations and conclusions based on additional information.

Key Concepts

- Excessive fertilizers and soil that wash into ponds have a negative affect on water quality and pond life.
- Introduced species often compete with native species and have a negative impact on both aquatic and terrestrial environments.
Prerequisites
*Investigating Interrelationships, Unit 2; Discovering Density and Diversity*

Activity at a Glance
Students gather data about water conditions and plant and animal species in the pond and summarize their findings.

Skills
observing, measuring, analyzing, interpreting data

Assessment
Students:
- Write a summary of data collected at the fishpond, including analysis of water quality tests and reports on density and diversity of plant and animal species found.
- Describe the consequences of human changes to the fishpond ecosystem and propose solutions to mālama (care for) the fishpond.

Time
2 class periods and 1-day field trip

Vocabulary
mālama - care for
mālama ola - means of support or livelihood; to support life
water hardness - total amount of dissolved minerals in fresh water measured as mg/L (milligrams per liter) or ppm (parts per million)
dissolved oxygen - molecules of atmospheric oxygen near the water surface that become mixed in and stay dissolved among the water molecules, expressed in milligrams per liter (mg/L) or parts per million (ppm)
salinity - the total amount of dissolved salts in brackish or sea water, expressed as grams of salts per kilogram of water (g/kg) or as parts per thousand (ppt)
algae - limu; aquatic plants and organisms containing chlorophyll
plankton - microscopic animal and plant life floating in bodies of water
phytoplankton - the plant organisms in plankton
pH - a measure of acidity and alkalinity of a solution that is a number on a scale on which a value of 7 represents neutrality; lower numbers indicate increasing acidity and higher numbers increasing alkalinity
diatom - unicellular or colonial phytoplankton with a silica based cell wall

Materials
Provided:
- pond life cards (see Appendices)
- coastal plant sheet
- student activity/data sheets
- group sharing - discussion sheets
Needed:
- pencils
- clipboards (one per group or have students use notebooks)
- rubber bands to secure papers to clipboard
- plant identification guides (see Resources)
- small container of rain water (optional)
- water test kits (see Resources)
- viewing tubes (optional, see Adaptations/Extensions in the previous lesson for instructions to make this simple equipment)

Advance Preparation

Copy the student activity sheet for each student. Make four sets of the student data sheets and one copy of the coastal plant sheet and group sharing discussion sheets for use during the field trip. Copy one set of pond life cards. Laminate the pond life cards and the coastal plant sheet.

Check with the school principal about taking students into the shallow water of the fishpond. Students have successfully participated in the pa'ipaoi netting activities and they get a lot more out of the field trip if they are allowed into the pond!

Contact the fishpond manager or field site coordinator (see field sites in Appendices) to schedule a site visit to the fishpond and to determine if equipment, such as nets and water test kits will be available at the sites. If you need to purchase water test kits, see the Resources listed at the end of this activity. Ask the manager or field site coordinator about the use of the data sheets provided with this activity since some sites may have data sheets designed specifically for use on-site.

Background

The shallow depth (two to three feet) of Hawaiian fishponds provides the optimal light conditions for plankton and limu growth. Natural fertilizers such as nitrogen, come from marine animal wastes in the pond. Minerals such as phosphate and calcium, come from incoming streams, and to a lesser degree from the tides, which also contribute salt (NaCl, or sodium and chloride). The fishpond mākahā (sluice grate) and pond walls were designed to allow water circulation from the tides. They allow water to circulate and prevent stagnation and the build-up of sediments, which is critical to maintaining a healthy, balanced fishpond ecosystem.

Natural Fertilizers

Limu and microscopic plankton provide food for the fish grown in the pond—the ‘ama‘ama (striped mullet) and awa (milkfish). The kia‘i loko (fishpond caretaker) guarded and cared for the pond, just as a farmer tends his pastures for cattle. In addition to the nutrients that occur naturally in the pond, the kia‘i “fertilized” the pond by adding additional food for fish such as kalo (taro), ‘ulu (breadfruit), uala (sweet potato), mussels and stones with limu.
**Excessive Nutrients**

Excessive nutrients from fertilizers can upset the balance of life in a fishpond by increasing the population of phytoplankton and limu (algae). If too many nutrients are added, algal blooms may form. These blooms can decrease clarity and light penetration, which causes limu to die. As the limu decompose, dissolved oxygen is depleted. Decreased dissolved oxygen then adversely affects the fish population. However, if algal blooms are rich in diatoms they can enhance the natural productivity of the pond. The diatoms in these blooms are nutritious and allow sunlight to warm the lower water layer and enhance natural productivity. According to Carol Wyban, (1992) “Chinese aquaculturists manage their water quality by color. Diatom-rich waters are a golden-brown color.”

If excessive nutrients increase the phytoplankton concentration to high levels, a potentially lethal situation occurs in the fishpond, especially during the night, when there is no sunlight and no wind or circulation. During the evening the phytoplankton that were making oxygen during the day, stop as the photosynthetic “machinery” shuts down. Because the phytoplankton are also alive and need oxygen to live, they begin to take up oxygen along with the other living organisms in the pond. If there is a large amount of fish, there will be almost no oxygen left in the water. This causes the fish to come to the surface of the water to breathe or gasp for air. Usually, in Hawai‘i, we are blessed with the trade winds, but during times of Kona winds, when there is almost no breeze and the water is still, catastrophic overnight fish kills in fishponds have been recorded due to the lack of oxygen in the water.

**Siltation**

Soil erosion from human activities near the fishpond may also have a negative impact on the fishpond ecosystem. Soil washing into the pond decreases the water clarity, blocking sunlight that the limu needs to grow. When the bottom sediments of soil and decayed organic matter in the fishpond get too thick, the sediment layer needs to be scraped toward the ‘auwai kai to be flushed out with the ebbing of the tide. This practice prevents the depletion of dissolved oxygen, which can occur when large amounts of organic matter are left to decay in the pond. When students net fish in the pond with the pa’ipai method (see prerequisite lesson, Investigating Interrelationships), they help to stir up sediments that are then washed out with the tide.

**Invasive Species**

One of the most visible invasive plants that students may observe at the fishpond is the introduced red or American mangrove (*Rhizophora mangle*). This small tree was introduced to Hawai‘i from seeds brought in from Florida in the early 1900s. Mangrove trees were introduced to the Islands to prevent soil erosion. The American Sugar Company planted seedlings on the upper slopes of Moloka‘i. However, the mangrove quickly spread to the coastline where it now thrives in brackish water on most of the Islands. The mangrove root system establishes itself within the walls of the fishpond. This causes sediment to be trapped, turning some fishponds into wetlands and mudflats. Mangrove also blocks sunlight, preventing the growth of limu, on which the ‘ama‘ama (striped mullet) feed.
Invasive limu species are also spreading on reefs and in fishponds, displacing native species and altering the structure of these ecosystems. Two of the most common aggressive species are *Gracilaria salicornia* and *Acanthophora spicifera*. See the pond life cards on these species and the information provided in the prerequisite activity, *Investigating Interrelationships*.

**Some Factors Affecting Fishpond Productivity**

- **water depth**: ponds two to three feet deep allow sunlight penetration that favors the growth of phytoplankton, zooplankton and limu.

- **water hardness**: minerals are dissolved in the rain water after it touches the ground. Water that is “hard” contains calcium and magnesium compounds. If rain water passes through soft rocks like chalk or limestone, it picks up these minerals. If it passes through hard rocks, such as granite or through peaty soils, it does not pick up these minerals and so remains soft. General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) of calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

- **salinity**: the salinity (amount of salts dissolved in brackish or sea water) fluctuates with tides, depths and proximity to freshwater streams and springs. Apple and Kikuchi (1975) reported a range of salinity in fishponds they studied to be from 2 to 32 ppt (parts per thousand).

- **circulation**: water circulates with the incoming tide to wash sediments out to sea and prevent stagnation and accumulation of bottom sediments. Bottom sediments are composed of silt and a layer of decaying detritus, or muck. These decomposing sediments take dissolved oxygen out of the water and produce hydrogen sulfide. These sediments appear as black mud that smells like rotten eggs. In areas of the pond with this decomposing layer, Apple and Kikuchi (1975) report that a hydrogen sulfide level above 3 ppm (parts per million) is considered injurious to young fish.

- **dissolved oxygen**: Apple and Kikuchi (1975) tested dissolved oxygen levels in 18 Hawaiian fishponds and found a range from 6 to 13 ppm. The mean level of 7.9 ppm indicated high levels of photosynthetic activity in the ponds. Like temperature, the level of dissolved oxygen will vary throughout the day with changes in temperature, light and cloud cover.

- **turbidity** (water clarity): the clarity of the water is related to the presence of mineral or organic particles suspended in water. Clear water allows sunlight to penetrate and the cooler water at the bottom to warm up. Cloudy water as a result of high turbidity reduces this sunlight and may reduce the growth rate of the limu, phytoplankton and fish.
• **pH:** the pH, (degree of alkalinity or acidity) of the water is measured on a scale of 1 to 14, with 1 being most acidic, and 14 being most alkaline. Due to the presence of minerals in Hawaiian waters, the pH of brackish water fishponds is generally alkaline (8.0 – 9.0).

• **water temperature:** the temperature varies seasonally and throughout the day. In a healthy pond, the temperature is relatively even in the water column and ranges from 64 to 88 degrees Fahrenheit in Hawai'i.

**Teaching Suggestions**

1. Divide the class into four groups and distribute the data sheets that students will use at the fishpond. Review the data sheets and discuss the tasks that students will complete at the pond. If students have not practiced using the transect and quadrat method described in the *Discovering Density and Diversity* activity, review it with them. If students made predictions about organisms they would find at the pond in the Unit 2 prerequisite lesson, review those predictions with the class.

2. Review the water quality tests that students will conduct at the pond. Introduce new vocabulary. If you have water test kits available, have students practice conducting the water hardness test, comparing tap water and rain water. Complete instructions are provided with the kits.

3. Discuss safety precautions and appropriate clothing and footwear for the field trip. Recommend that students wear old clothes that can get dirty, covered shoes or tabi, and sunscreen and/or a hat.

4. Discuss proper protocol for visiting the pond and the need to mālama (care for) the environment and one another. If students know an oli (chant) that would be appropriate to share with the fishpond coordinator or manager upon arrival, review the chant with them. See the *Haku Mele Aloha* activity in Unit 3, Grades 4 – 5, for suggestions on composing simple mele in Hawaiian.

5. Distribute the student activity sheet on mālama and ask students to complete it as homework before visiting the pond.
Investigations at the Pond

- Remind students of the cultural significance of the site they will be visiting and the need to treat it with respect. Students should be reminded that some fishpond walls are very fragile and could shift or settle when stepped upon.

- At the fishpond, students in groups A and B will work at the pond life station and students in groups C and D will work at the plant life station. After about an hour, the groups will switch stations. Group A will switch tasks with group C and group B will switch tasks with group D.

Pond life station – Students collect data on water conditions and living organisms in the loko i’a. Group A will study water hardness and salinity. Group B will study dissolved oxygen and plankton. Both teams will be conducting tests simultaneously and then share their results with one another. Use the questions and answers provided on the group sharing discussion sheet to summarize.

Plant life station – Students will work in two groups. Group C will run a transect in the shallow water of the pond and estimate the percentage of cover for different types of limu. Group D will run a transect in another area to study the plants growing next to the pond. The two groups will then share with each other - demonstrating their methods and what they learned. Use the questions and answers provided on the group sharing discussion sheet to summarize.

- The final session will be with the entire class participating in catching fish in the pond using the pa‘ipa‘i method to gather fish in a large net. The site coordinators will work with students to teach them this method of catching fish.

After Visiting the Fishpond

6. Ask groups to report on their findings at the pond. If they were unable to identify a species at the pond, have students use their notes and sketches and look it up (see Resources). Ask students to use their data to create graphs illustrating the diversity and density of species found. Encourage them to use the computer to display their data appropriately and clearly.

7. Have students write their conclusions about the fishpond based on their data and complete the assessment activity. Discuss the culminating activity (see Unit at a Glance).
Adaptations/Extensions

- Arrange to collaborate with other schools on the study of water hardness and/or pH in regard to rain water on the Big Island versus rain water on the other islands. Acid rain resulting from the vog will have a different pH. Other simple studies of pH can include a comparison of rain water only, rain water plus kamani tree leaves; tap water only and tap water plus kamani tree leaves. The effect of kamani tree leaves on pH can be compared to the native use of hau tree leaves in the lo‘i kalo. Between plantings, Hawaiians mixed hau tree leaves with soil and left the lo‘i fallow for a period of time. The leaves added nutrients but also lowered the pH of the soil. This was figured out by trial and error using things in the environment long before modern-day scientific studies.

- Have students conduct simple tests comparing buoyancy in salt water versus tap water using a water hydrometer. If a hydrometer is not available, use some capped, plastic test tubes marked with gradients. Place sand or lead in the tubes to the amount that will allow the tubes to float upright in tap water. Then place the same tubes in salt water, and see which are more buoyant. (The tube will float higher and lean to one side in the salt water.) If sea water is not readily available, add Hawaiian sea salt to tap water (to reach a salinity of 50 ppt). (Note: Salinity hydrometers can be purchased through Aquatic Eco-Systems for about $8.00 plus shipping. If ten are more are purchased, the price drops.)

Resources

Aquatic Eco-Systems, Inc. <aes@aquaticeco.com> http://www.aquaticeco.com/ (Source for throw nets, aquaculture supplies and equipment)


Hach Company. <orders@hach.com> www.hach.com/ P.O. Box 389, Loveland, CO 80539 (800) 227-4224 or (970) 669 3050. (Analytical systems and technical support for water quality testing, with solutions for lab, process, and field)

LaMotte Company. <mkt@lamotte.com> www.lamotte.com/ P.O. Box 329, 802 Washington Avenue, Chestertown, MD 21220 (800) 344-3100. (Products for the analysis of water, soil, and air)


University of Hawai‘i at Mānoa Botany Department. Hawaiian Reef Algae. (Copyright © Gerald D. Carr) <gerry@hawaii.edu> http://www.botany.hawaii.edu/reefalgae/ (Click on Marine Plant Research, Hawai‘i Coaral Reef Initiative for invasive algal species.)
Student Data Sheet - Groups A & C

Name ___________________________________________ Date_______

**Pond Life Station**

**Water Hardness (minerals in water)**

- Use the test kit provided.
- Read safety information and follow instructions in the kit for testing each sample.
- Record the water hardness in ppm (parts per million).

<table>
<thead>
<tr>
<th>tap water</th>
<th>rain water</th>
</tr>
</thead>
</table>

What could account for the difference in water hardness of the two samples?

**Salinity**

- Use the 4 SeaTest Specific Gravity Meters, one for each sample (see Resources).
- Pour water into the meter. Tap it gently to get the bubbles out.
- Record the salinity in ppt (parts per thousand).

<table>
<thead>
<tr>
<th>tap water</th>
<th>stream</th>
<th>loko i’a</th>
<th>ocean</th>
</tr>
</thead>
</table>

What causes salinity to be different in the samples?

How is hardness related to salinity?

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Dissolved Oxygen

- Set up two containers: one with fresh water, and one with pond water.
- Measure and record the salinity of each water sample.
- Use the dissolved oxygen meter (handle carefully — it’s expensive).
- Check to see if the meter has stabilized (around 7 ppm) before using.
- Turn on the bubblers and place one hose in each container.
- Measure and record the dissolved O₂ levels in ppm (parts per million) in both water samples.

What could cause the dissolved oxygen to be different for the samples?

When do you think dissolved O₂ is higher in the pond – day or night? Why?

Add 10 - 15 small fish to the container with pond water. Remove the bubbler. Record the dissolved O₂ levels. What do you observe about the behavior of the fish once the dissolved O₂ level goes below 4 ppm? What types of human activities might cause the dissolved O₂ level to drop in the pond?

Life in the Pond: Plankton

- Place the plankton net in the current found in the ‘auwai kai. Wait for 10 minutes.
- Carefully remove the plankton net and pour water from the container at the bottom of the net into a jar.
- Use a pipette to transfer the water into test tubes.
- Look at tubes through magnifiers.
- Count the number of zooplankton in the test tube. Compare your findings with those of the other students.

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<thead>
<tr>
<th>Types of Plankton</th>
<th>No. of zooplankton in the test tube</th>
</tr>
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</table>

<table>
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<tr>
<th>stream</th>
<th>loko i‘a</th>
</tr>
</thead>
</table>

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Group Sharing – Discussion Questions

Report from Groups A & C:

• What is water hardness?  
  (minerals in the water)

• What are the results?  
  (Tap water is approximately 150; Rain water is about 50. Results will vary.)

• Why are the samples so different?  
  (Tap water contains minerals that have collected in the rain water as it seeps through the ground.)

• Why is salinity different in the samples?  
  (Salinity – the amount of mineral salts dissolved in the water – fluctuates with tides, depths and proximity to freshwater streams. Researcher Kikuchi found 2 – 32 ppt for fishponds.)

• How is salinity related to water hardness?  
  (The saltiness of the ocean is from dissolved minerals, including runoff from the land.)

Report from Groups B & D:

• Why is dissolved O₂ less in salt water than fresh water?  
  (Dissolved minerals in salt water take up space where O₂ would be. Researcher Kikuchi found a range 6 – 13 ppm dissolved O₂ in fishponds.)

• When is dissolved O₂ higher in the pond – day or night?  
  (The level of dissolved O₂ varies; it’s higher during the afternoon when photosynthesis has been occurring for awhile; lowest at night when photosynthesis stops.)

• What did you observe about fish behavior when dissolved O₂ drops below 4 ppm?  
  (The safe zone is above 3 ppm. Below that fish have a hard time breathing and come to the surface for air.)

• What is the role of phytoplankton in the fishpond?  
  (primary producer of dissolved O₂ and a source of food)

• How does the amount of phytoplankton in the pond affect the level of dissolved O₂?  
  (Phytoplankton increase dissolved O₂. However, an increase in nutrients can cause excessive phytoplankton growth and algal blooms, which decrease clarity and light penetration, causing limu (algae) to die. When excess limu and phytoplankton decompose, dissolved oxygen is depleted. When the phytoplankton concentration is high, and there is no sunlight, wind or circulation, available oxygen gets used up and fish come to the surface to breathe. During times of Kona weather when there is almost no breeze and the water is still, catastrophic overnight fish kills have been recorded due to the lack of oxygen in the water.)
Group Sharing – Discussion Questions (cont.)

(Why is the shallow depth of a Hawaiian fishpond an ideal place for plankton and limu growth? (Sunlight, which is essential for photosynthesis and growth, is able to penetrate to the bottom of the pond.))

(What are the natural “fertilizers” that keep the plankton and limu growing? (Wastes from organisms growing in the pond, trace minerals dissolved in fresh water))

All Groups Report

(What kinds of fish were caught in the net using the pa‘ipa‘i method? (Note: the pa‘ipa‘i method will only catch the larger-size fish. Most of the fish in the pond are small and will be able to escape the net.))

(Which fish were most common? Which were least common? How does this fit with the predictions we made in class about the species of fish we would find?)

(How does the pa‘ipa‘i method we used to catch the fish benefit the pond? (The silt that is stirred up by people in the pond is washed out with the ebbing tide. This helps to clean the pond and allows for more dissolved oxygen to be available to the fish.))

phytoplankton
Sampling Limu

1. Lay the rope transect out along the pond wall in the area designated. Place the quadrat in the water next to the pond wall at the beginning of the transect.

2. Use the pond life cards to identify and record the limu species that you find within the quadrat. If you are unable to identify a limu species, sketch it and give it a name. (Make a detailed sketch to refer to when you research the type of limu back in class.)

3. Estimate and record the percentage of area that each species covers within the quadrat. Then move two meters along the line, place the quadrat down and record again. Repeat the process until you have sampled at least three areas.

Use the pond life cards to identify limu species. Sketch limu that you cannot identify. Note: if you have look boxes or viewing tubes available, use these to help you view limu underwater. The sediment that is stirred up when walking in the pond will clear if you stand still for several minutes.

<table>
<thead>
<tr>
<th>Sample Area</th>
<th>Plant Species Found Status (E=endemic, Ind.=indigenous, Int.=introduced)</th>
<th>Percent Cover (for each species)</th>
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Sampling Plants Growing Around the Pond

1. Lay the rope transect out along the pond wall in the area designated. Place the quadrat at the beginning of the transect. Line one side of the quadrat up with the edge of the rope.

2. Use the coastal plant sheet to identify and record each plant species that you find within the quadrat. If you are unable to identify a plant, sketch it and give it a name. (Make a detailed sketch to refer to when you research the type of plant back in class.)

3. Within the quadrat, count the number of each type of plant, or record the percentage of area that the species covers. Then move two meters along the line, place the quadrat down and record again. Repeat the process until you have sampled at least three areas.

Use the coastal plant sheet to identify plants. Sketch plants that you cannot identify.

<table>
<thead>
<tr>
<th>Sample Area</th>
<th>Plant Species Found Status (E=endemic, Ind.=indigenous, Int.=introduced)</th>
<th>Percent Cover (for each species)</th>
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Coastal Plant Sheet

‘Ākulikuli  
Hinahina  
Milo

Mangrove  
‘Ākulikuli Kai  
Niu

Indian Plucheia  
Silver Buttonwood  
Waina Kahakai
Coastal Plant Descriptions

1. ‘Ākulikuli (indigenous)
   *(Sesuvium portulacastrum)*
   This plant grows along the ground, trailing its branches and fleshy stems. It bears a purple flower. The fleshy parts are edible and can be eaten raw or cooked as greens.

2. Hinahina (indigenous)
   *(Heliotropium anomalum var. argenteaum)*
   The hinahina has grayish silvery leaves and white flowers, which are sometimes used in lei making. If the kōko’olau (beggar ticks) plant was not available, early Hawaiians would brew the leaves of the hinahina to produce a tonic tea.

3. Milo (Polynesian introduced)
   *(Thespis pubulnea)*
   Milo seeds provide a laxative, and the young leaves can be cooked or eaten raw. The dry globular fruits are not eaten at all. The yellowish flowers will wilt as the day progresses, shriveling and turning to a purplish pink color.

4. Mangrove (alien)
   *(Rhizophora mangle)*
   Mangrove was introduced to the Islands in 1902. Their aerial roots trap sediments, which hold together and extend the land area. However, these plants are choking traditional Hawaiian fishponds. The bark and shoots can be used to produce dye.

5. ‘Ākulikuli Kai (alien)
   *(Batis Maritima L.)*
   The pickleweed is a small woody plant with fleshy leaves. It is edible and can be used in salads. Pickleweed is known to have medicinal value. In the Caribbean, it is used to make soaps and glass products.

6. Niu (Polynesian introduced)
   *(Cocos nucifera)*
   The coconut palm sometimes reaches heights of 100 feet. It has many uses; the coconut fruit is used as a food source and the fronds are used to make baskets. In old Hawai’i, women were forbidden to eat the milk and meat of the niu.

7. Indian Plucheia (alien)
   *(Plucheia indica)*
   This plant was recently introduced to Hawai’i. It is a native of southern Asia. Indian plucheia can be found near coastal areas; look for the pink or purple flowers clustered at the branch ends.

8. Silver Buttonwood (alien)
   *(Conocarpus erecta sericeus)*
   This plant grows in or near salt or brackish water and is tolerant of full sun, sandy or alkaline soils. The velvety leaves have silver hairs. The red-brown cone-like fruits are not edible. The wood is excellent for making charcoal and for smoking fish and meat.

9. Waina Kahakai (alien)
   *(Coccoloba uvifera)*
   The sea grape is known as the “autograph” tree because marks on new leaves produce white lines. The fruit is made into jelly and alcoholic drinks. The root is used medicinally to cure dysentery. The bark is used as medicine to soothe soar throats.
Group Sharing – Discussion Questions

Plant Life Station

(copy 1 sheet for teacher)

- What species of limu (and plants) did you find?
- Which were most abundant? Which were least abundant?
- Were there any differences between the areas that you sampled? If so, what factors might account for those differences? (For example, in the pond – proximity to currents; on the pond wall – protection from salt spray, shade versus sun, depth of soil)
- How could we use the data collected to estimate the density of plant species in the fishpond and along the shore? Calculate the density for the most common species found.

\[
\text{Density} = \frac{\text{# of individuals}}{\text{area}} \quad \text{or} \quad \frac{\text{total % covered in quadrats}}{\text{area}}
\]

To calculate the density, count the total number of plots sampled and determine the area in square meters. For example, if 3 areas were sampled, the total area is 3 square meters. If 60 individuals were counted the density would be 20 plants per square meter. If students are using percent cover, have them add the total percent cover for each species and divide this by the area – the number of meters sampled.

- Was the species with the highest density native or introduced?
- What impacts are introduced plants having in the fishpond and the surrounding environment? Explain your ideas.

(Introduced or alien plant species that are invasive in a habitat, crowd out native species of plants, which often affects the interrelationships among native plants and animals.)
Student Activity Sheet

Name ________________________________ Date __________

Mālama

Mālama means to care for, preserve, protect, tend to, and support.

- E mālama i ka ‘āina. (Care for the land.)
- E mālama i nā keiki. (Take care of the children.)
- E mālama i ke Akua. (Serve the divine.)
- E mālama pono ‘oe. (Take good care of yourself.)
- E mālama i kou kino. (Take care of your body.)
- E mālama kekahi i kekahī. (Watch out for one another.)

In our day and age, we tend to forget this one important concept of mālama (caring). How do we care for each other, especially our families? How do we take care of our ‘āina (land) and our honua (Earth)? Do we mālama those things that are so important to our life—he ola pono (to a good life)? Do we always take, or do we give back with aloha and sincerity? My kūpuna (ancestors) survived in harmony with their environment. I must keep that concept of mālama ‘āina, mālama ke Akua, and mālama i ka ‘ohana (family) within my heart and soul, so that I can guarantee my children a good life for their future. I hope you have it in your heart to do the same.

E mālama pono ‘oe! E mālama kekahi i kekahī! Aloha.
Keoni K. Inciong-1997

What does mālama mean in this reading? Have you heard the word mālama used before? Give examples.

Is mālama a part of your family’s life style? Why might it be difficult to maintain that value? Give examples.

How do you express mālama for the ‘āina? Give examples.

Share this reading with a family member or adult friend and record their response to it.