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ABSTRACT

Designed to help teachers implement marine education in their classrooms, this module provides information regarding a vanishing Hawaiian resource, fishponds. Due to the impact of present day human activities on shoreline areas, the size and number of fishponds have been greatly reduced; therefore, this module focuses on fishponds as a resource management tool. Descriptions are provided of the biological and physical features of fishponds. Activities are presented by the topic areas of: (1) plants in the fishpond food system; (2) fishpond sediments; (3) animals living in the sediment; (4) fishpond predators; (5) mangroves; (6) mullet; and (7) fishpond construction. Activities contain a learning objective, material list, procedures, and in most cases discussion questions. A bibliography is included and appendices consist of an identification guide to common fishpond inhabitants and a field trip to Ali'i Fishpond. (ML)

MOLOKA'I: FISHPONDS

Environmental Education

Office of Instructional Services/General Education Branch • Department of Education • State of Hawaii • RS 86-9904 (Rev. of RS 84-6210)
June 1986

FOREWORD

Moloka'i: Fishponds, an instructional module, provides information regarding a vanishing aquatic resource.

Fishponds were an important means of managing a food resource for the early Hawaiians. There were a large number of these productive ponds scattered throughout the islands. However, with the impact of present day human activities on shoreline areas, the size and number of fishponds have been greatly reduced. Ironically, because of human's use of land and the concern over the size of the world's population, we are turning to the sea for additional food resources. A look at fishponds as a resource management tool of the past may provide direction for the future.

Although the module is directed to the intermediate school students, the materials contained within the module may be used with upper elementary students. It is hoped that teachers will use this module as an aid to implementing marine education in their classrooms.

Francis M. Hatanaka
Superintendent
Department of Education

ACKNOWLEDGMENT

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MOLOKA'I: FISHPONDS

Introduction

Fishponds are interesting study sites where they are available. Class studies can combine such diverse areas as Hawaiian history, science, math, aquaculture, and cooking. Fishponds provide safe places for field trips, as they are generally shallow and protected from waves. The types of animals found in a fishpond are quite different from those found in areas generally visited during shoreline studies.

BACKGROUND INFORMATION

Since legendary times, fishponds have been an important source of food for Hawai'i's people. No other Pacific Island culture produced as many types and numbers of fishponds as the early Hawaiians. By the end of the 18th century, more than 360 ponds were owned by high chiefs alone. Ownership of fishponds was one of the status symbols of ancient Hawai'i. Fishponds owned by Hawaiian royalty were the largest and most carefully constructed. Consequently, they have proven the most durable, accounting for almost all of the comparatively small number of surviving ponds. Although there is conflicting opinion, royal ponds and their products appear to have been kapu to the vast majority of early Hawaiians (Apple and Kikuchi, 1975). Commoners and lesser chiefs, however, enjoyed the catch of fishes from large numbers of smaller ponds. Many of these were freshwater lo'i or taro (kalo) paddies which were stocked with juvenile mullet ('ama'ama), milkfish (awa), surf perch (aholehole), and gobies (o'opu) and harvested together with the taro.

Hawaiian coastal fishponds were constructed in most cases by walling in a suitable section of shallow reef. Exchange of water and marine life between the open ocean and the pond was generally regulated by water control gates or makaha. Most ponds were constructed of coral rock and lava boulders which were loosely laid without mortar allowing an exchange of water through the walls. Ponds were stocked by movement of juvenile fish seeking refuge in the protected pond when water gates were opened and by transfer of young fish, especially mullet, captured by net outside the pond (Hiatt, 1944).

The grey mullet (Mugil cephalus), is the most important of the fishes raised in fishponds throughout Hawaiian history and into modern times. These fish are ideal as culture species for several reasons. They are tolerant of a wide range of salinities, so they can survive fluctuations which are common in ponds receiving freshwater runoff from the land. Mullet are fast growing and many reach a marketable size of 3/4 pound in an average of 12 months. Most importantly, mullet feed on living and decaying plant matter, so they are able to graze on the thin mat of minute algae which grow on the shallow bottoms of fishponds. Many of the seafoods consumed by humans are near the top of the food pyramid which progresses upwards from plant life. Energy is lost in the progression to flesh-eating fishes near the top of the food pyramid; thus, many plants and small animals are required to produce a few, larger animals. Mullet and other fishes raised in fishponds consume plant-life directly, thereby telescoping the usual food pyramid progression and providing a far more efficient system of food production (Madden and Paulsen, 1977). (Fig. 1)

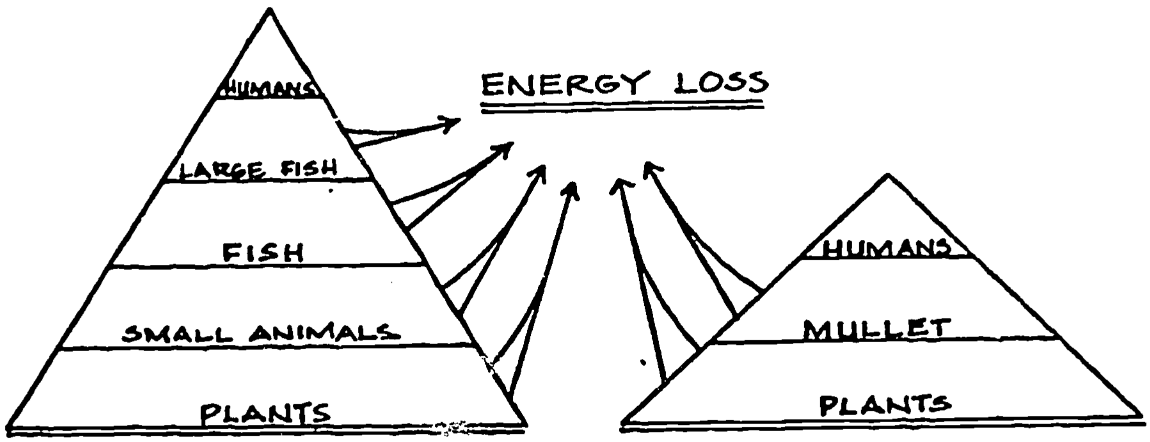

Fig. 1

Although fishponds were important food production systems for early Hawaiians, most of the ancient fishponds have fallen into disuse, or have been converted to other uses in modern times for various reasons. Consequently, pond production of mullet and other food fishes is only a fraction of what it once was. A little more than 1,000 pounds of mullet were produced in fishponds in a recent year, compared to a yield of 485,000 pounds for one year at the turn of the century. The decline in pond production can be attributed to the loss of humanpower skilled in pond management, deterioration of the physical integrity of pond walls and water control gates, as well as land use changes in the areas surrounding the fishponds, such as urbanization, industrialization, ranching, deforestation, accelerated soil erosion and subsequent siltation of the ponds, overgrowth by mangrove trees, and water pollution. Economic factors, such as the increasing value of shoreline real estate and the high cost of labor to maintain and operate fishponds, have also contributed to the general disrepair (Apple and Kikuchi, 1975). In addition, conversion from ponds to housing sites and marinas has occurred. Further destruction due to tsunami activity and land subsidence is an important factor in some areas.

Physical Setting

The largest number of surviving Hawaiian fishponds is found along the southern coast of Moloka'i, east of the town of Kaunakakai (Fig. 2). There, fishponds vary in their condition and upkeep. One of these, Ali'i Pond, (Fig. 3), although neglected and not operated for food production for many years, is in reasonably good condition. The Oceanic Institute acquired rights to use Ali'i Pond and in 1966 completed repairs on 300 feet of the old rock wall and the construction of two screened water gates to restrict the flow of water and marine life from the outside shallow reef flat through the porous wall. The bottom of the pond was partially dredged to provide fill for wall repair (Van Heukelem, 1968).

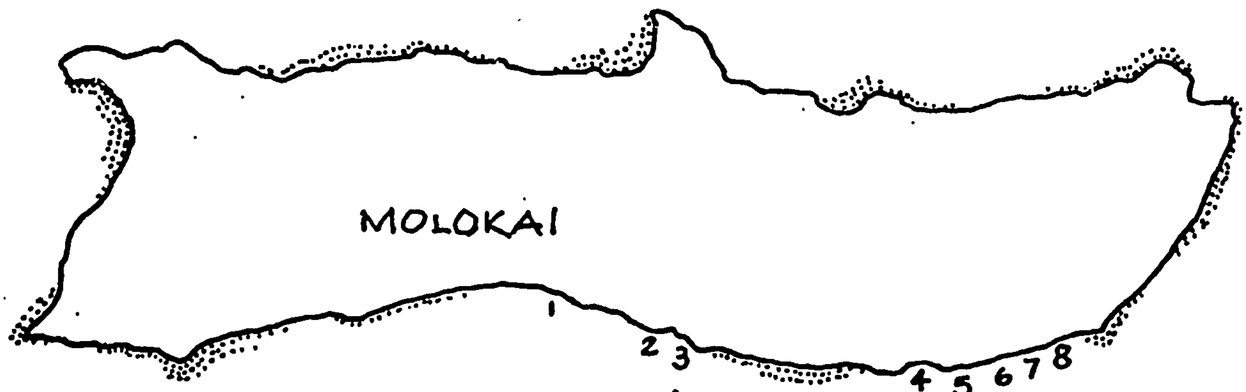

Fig. 2

1. Kaluaapuhi
2. Kaloko'eli
3. Alii
4. Kalokoiki
5. Ualapue
6. Kaopeahina
7. Niaupala
8. Kupeke

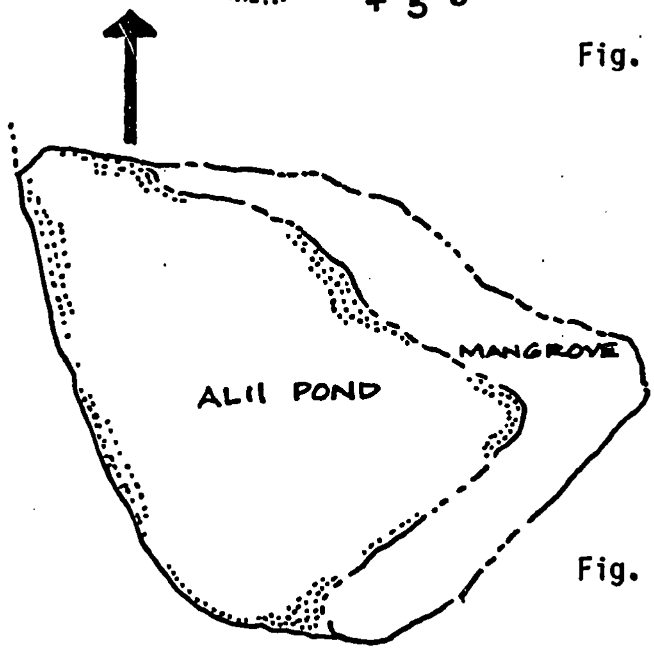

Fig. 3

Originally, the pond's area was about 26 acres, but invading mangroves have reduced its water area to about 18.5 acres at present. Like most of the fishponds along the southeast shore of Moloka'i, Ali'i Pond was built by enclosing a semi-circular area of the reef flat with a wall of loosely laid lava and coral rocks. The pond bottom is nearly level and quite shallow, ranging from 4 to 40 inches (10 to 100 cm) in depth depending on the tide. Ali'i Pond has experienced heavy silt accumulation during the latter half of the 19th and early 20th centuries as a result of overgrazing and accelerated erosion rates in the upland areas that drain to the ocean. The soft, muddy bottom of Ali'i Pond consists of a 2 to 22 inch (5 to 56 cm) thick layer of fine silt overlying coarse sand and shell fragments on the original reef flat. The average depth of the silt layer is 10 inches (25 cm). The original reef flat outside the fishpond walls is covered by up to 14 inches (35 cm) of sandy mud (Van Heukelem, 1968).

The loosely constructed rock walls of Ali'i Pond originally allowed relatively rapid exchange of water with the ocean (Madden and Paulsen, 1977). This has been reduced due to partial reconstruction of the wall during

1970-1971 when silt from the bottom of the pond was compacted to form an impervious wall along a large portion of the old sea wall. This double wall now reduces water exchange between the pond and the ocean. Normal salinities of pond water range from 32 to 34 parts per thousand, but may drop as low as 26 parts per thousand after heavy rainfall. (Ocean water ranges from 33 to 35 ppt.) Freshwater seeping into the pond from springs along its shoreline perimeter lowers salinity in a small area near shore to 18 parts per thousand during low tide. Water temperatures average 28-29 degrees C., but can reach 41 degrees C. in shallow areas of the pond during low tides on calm, cloudless days when winds do not blow. (Ocean water ranges between 24-27 degrees C.)

Biological Setting

The soft bottom of Ali'i Pond supports a different form of marine life than hard bottoms and rocky shores that are the usual focus of nature study in Hawai'i. The dominant groups of life in Ali'i Pond cope with the soft bottom by digging and inhabiting burrows which provide the only stability in a shifting, generally inhospitable bottom (Van Heukelem, 1968). The pond has high numbers of a small goby fish (Oxyurichthys lonchotus) and snapping shrimp (Alpheus lobidens). The gobies are spread throughout the muddy pond bottom while the snapping shrimp are abundant only in the shallows. Palaemon debilis, the most common shrimp in the pond, can be found in dense aggregations in the shallows around the edges. The blue pincer crab, Thalamita crenata, is the most common crab.

At least 14 species of flesh-eating animals (carnivores) roam Ali'i Pond in search of prey. Barracuda (Sphyraena barracuda) and papio (Caranx ignobilis) are the most abundant of the predatory fishes. The blue pincer crab is the most important flesh-eating crustacean. Other less common carnivores inhabiting Ali'i Pond include 'awa'awa or ladyfish (Elops hawaiiensis), 'o'io or bonefish (Albula vulpes), lizard fish (Saurida gracilis), needle fish (Strongyleura gigantea), nightmare weke or goatfish (Upeneus arge), la'e (Scomberoides laysan), o'opu akupa (Eleotris sandwicensis), goby (Bathygobius fuscus), cardinal fish (Apogon brachygramma), flatfish (Bothus pantherinus), and snapping shrimp (Alpheus lobidens). In addition, black-crowned night herons hunt small fish and invertebrates along the margins of the fishpond when the tide is low and the water calm. They are concentrated along the eastern shore, possibly because mangrove thickets provide protection from tradewinds and provide calm water in which to hunt their prey (Van Heukelem, 1968).

TOPIC I: PLANTS IN THE FISHPOND FOOD SYSTEM

The food production system of a fishpond depends on plants, especially minute forms of seaweeds called diatoms. Diatoms and other seaweeds form a thin mat over the shallow bottoms of fishponds and carry out the same activities as any shrub or tree on land: they use sunlight to produce energy in the form of plant tissue, which serves as the first step in the pond's food pyramid. Thus, energy to run the system comes from the sun.

The biomass, or total amount, of plant life depends not only on light, but also on the availability of nutrients. Just as plants on land cannot survive without mineral nutrients, such as fertilizers, in the soil, seaweeds require the same minerals in surrounding waters. Seaweeds absorb nutrients directly through their fronds or "leaves" rather than through roots. The nutrients which are usually in greatest demand are phosphorous and nitrogen, the same basic fertilizers used on lawns.

The Nutrient Cycle

Nitrogen and phosphorous never disappear from the nutrient cycle; rather, they are simply converted from organic (compounds containing carbon) to inorganic forms. As inorganic nutrients, they circulate in the pond water and are absorbed by plants. Through the process of photosynthesis, they are woven into essential organic compounds and incorporated into the body of the plant.

Once a living organism, such as a plant, dies its body is attacked by bacteria. These bacteria cause the living material to decompose, releasing nutrients from their organic bonds. The nutrients are then free to continue the nutrient cycle (Fig. 4).

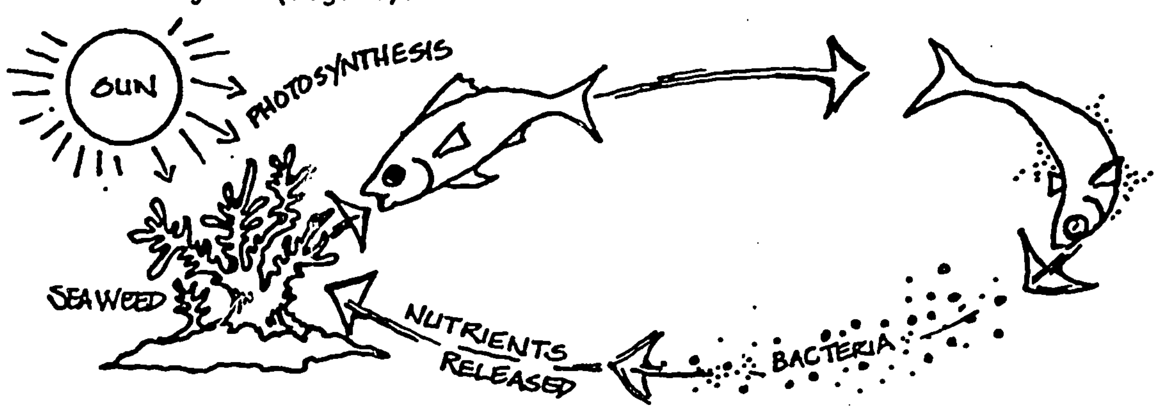

Fig. 4

There is generally no shortage of nutrients in enclosed water bodies, such as fishponds, where water exchange with the open ocean is controlled by gates. However, the supply of plants (algae) available for consumption by mullet and other grazing species can be increased by the application of fertilizers. Intensive pond management, including supplemental feeding of fish and fertilization of algae, can increase the yield of fish by as much as ten times over unmanaged ponds.

Very shallow waters (1-2 feet deep) may enhance plant growth due to higher temperatures and greater light penetration. However, the fish need some deeper areas as high water temperatures may be lethal during low tides on days of clear skies and no winds.

While the sheltered environment of a fishpond generally enhances plant growth, turbidity there may pose problems. Where water movement is sluggish, small particles of suspended plant matter settle out on the bottom, contributing to the accumulation of silt and detritus. There, deposits are easily agitated by wind and other disturbances. When trade winds are blowing, fine sediment on the bottom is stirred up, so pond waters are frequently turbid. Under these conditions, penetration of sunlight can be the factor limiting the growth of plants consumed by mullet and other herbivores. In Ali'i Pond, good plant growth is restricted to shallow areas not over 1 or 2 feet in depth. At greater depths, turbidity limits plant growth by blocking light reaching the pond bottom.

The effect of bottom disturbances on water turbidity and sunlight penetration can be the focus of a class activity during a field visit to Ali'i Pond. See Appendix 2 for field trip information.

Activity 1-1

TURBIDITY METER

Objective: To build an apparatus to measure turbidity in the pond.

Materials:

Volt-Ohm meter
Cadmium sulfide photo cell
Block of soft wood 15 cm x 10 cm x 10 cm
Test tubes
Drill
Epoxy cement
75 or 100 watt light source

Procedure: (Reprinted with permission from Rasmussen, 1978.)

1. Make a photometer to measure turbidity of coastal waters. You will need an inexpensive volt-ohm meter (VOM), a cadmium sulfide photo cell, and a block of soft wood (pine) about 15 cm long and 10 cm square. You will also need some test tubes to carry out your experiments. Fig. 5 shows a diagram of the photometer.

2. At one end of the block, drill a hole that is centered and goes almost through the length of the wood. The diameter of the hole should be slightly larger than 2.6 cm so it will accommodate a large test tube.

3. Next, drill a hole at right angles to the first hole and passing through it so that the paths cross. The second hole should go through the wood from side to side. The diameter of this hole should allow the photo cell to fit tightly.

4. Push the photo cell into one of the side holes a short distance and secure it with epoxy cement.

5. Attach the leads of the VOM to the leads of the photo cell and you are ready to test your turbidometer.

6. Shine a light through the wood onto the surface of the photo cell.

7. Set the selector of the VOM on R x 1, Ω, or R. The needle of the meter should deflect. An ideal bulb size for a light source is 75 or 100 watts. Determine the most effective distance of the light source from the meter by trial and error.

8. Now you are ready to introduce test tubes of turbid water into the turbidometer. The more turbid the water is, the less is the light that will reach your photo cell and the less the needle will deflect.

9. Compare samples from different places along your coast. Graph your data. If you use the Ω or R scale, use semi-log paper.

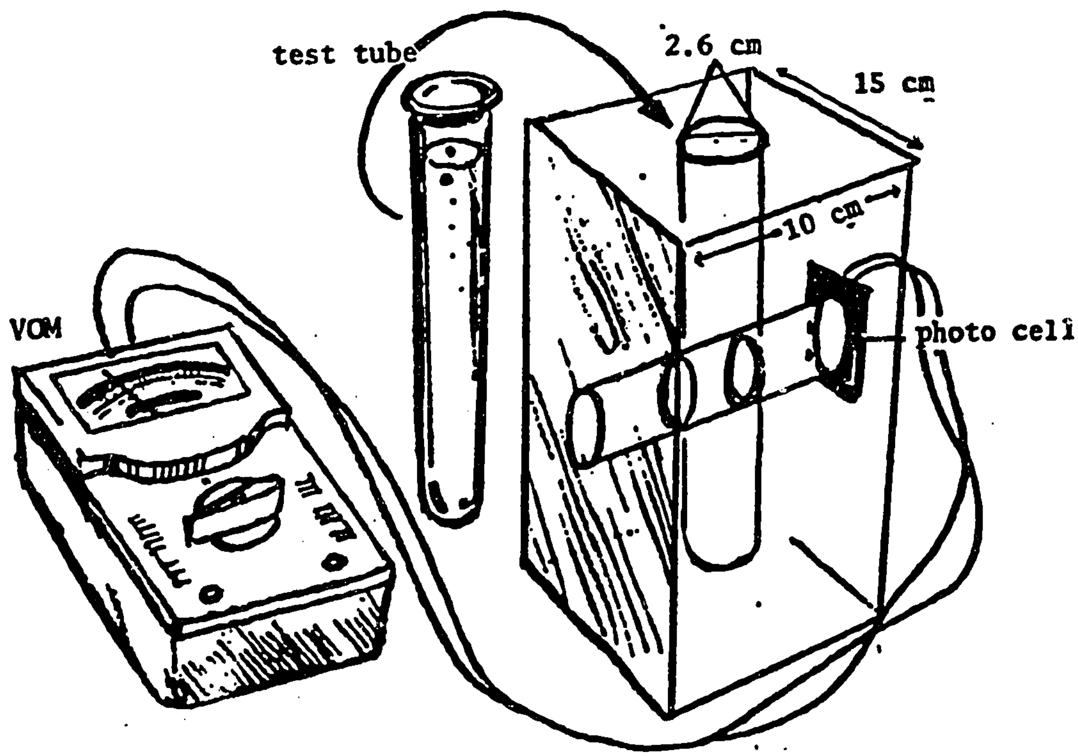

Fig. 5

Activity 1-2

MEASURING TURBIDITY, SALINITY, AND ANIMAL POPULATIONS

Objectives: To measure turbidity and salinity in the fishpond.
To observe physical effects of the environment on the distribution of animals in the pond.

Materials:

Photometer (made in previous activity)
75 or 100 watt light source
Opae nets
Thermometer
Hydrometer
Buckets
Test tubes

Procedure:

1. Measure salinity (density and temperature) along the shoreline near the mangroves, along the shoreline half-way between mangroves and gate, inside the makaha, and on the shallow reef about 20 paces outside the makaha. (Refer to Appendix G in the Kauai: Streams and Estuaries guidebook.)

2. Compare sediments at all four places.

3. Use opae net and sieve the bottom for animals at all four places, and give a name to every different kind of animal found. Make a count of the animals found; however do not overcrowd the animals in the containers in which they are collected or keep them too long.

4. Return the organisms to the areas when finished with the observations and measurements. Watch to see if they burrow in or swim away when you let them go.

Sample Data Sheet

	Mangroves	Halfway	Makaha	Outer Reef
R Scale Reading				
Temperature				
Density				
Substrate Type				
Animals (No. & Type)				

Questions:

1. Was there a difference in salinity? Try to explain any differences found. (Less salty near mangroves due to freshwater springs.)

2. Was there a difference in substrate types? (Usually muddier near mangroves, coarse sand near makaha.)

3. Were there differences in animals found? (The distribution of animals may be affected by the differences in salinity and substrate types found in the areas. Burrowing forms often prefer mud.)

4. How many types of opae were present?

5. How many types of crabs were present?

6. How many types of fish were found?

Activity 1-3

NUTRIENTS IN THE WATER

Objective: To measure levels of the nutrients nitrate and phosphate.

Materials:

Nitrate Test Kit
Phosphate Test Kit
(Both kits are available through biological supply companies.)

Procedure:

Follow the directions as indicated in each of the kits.

Questions:

1. Why is it important that the water in a fishpond contain nutrients like nitrate and phosphate?

2. How do these nutrients get into the water?

3. Why do pond managers fertilize the water in the fishpond?

TOPIC II: FISHPOND SEDIMENTS

Like most Hawaiian fishponds, Ali'i Pond has a soft bottom, consisting of deposits of silt and silty-sand about a foot thick overlying sand and shell fragments. The soft overburden is a mixture of soil derived from land run-off, sand of marine origin, and considerable organic muck derived largely from decaying plants. Since plants contain chemically resistant materials (humus) and their bodies persist after death, they are added to the bottom, where disintegration proceeds slowly. Heavy sediment accumulation in Ali'i Pond and most other fishponds has contributed to their disuse. In prehistoric times, the layer of sediment and muck periodically was removed from fishponds by commoners and lesser chiefs and public works projects.

Physical characteristics, especially water turbidity and the stability of soft bottom deposits, help to determine the abundance and types of bottom dwelling creatures. The soft bottom of Ali'i Pond is less frequently disturbed by water movement than the sandy mud covering the shallow reef outside the pond, which is exposed to greater water motion. Comparison of the soft bottom inside and outside the pond wall during a field visit will reveal a larger proportion of small, light particles (mud) within the sheltered pond environment. On the more exposed reef flat, sediment deposits will contain a larger proportion of sand and less mud.

Activity 2-1

SEDIMENTS

Objective: To compare sediments inside and outside the fishpond.

Materials:

Two glass jars for each team of students (16-32 oz.)

Procedure:

1. Scoop up sediment from the pond in one jar and from outside the pond in another jar. Jars should be about 1/2 full. Add water to fill the jars 3/4 full.

2. Shake the jars well, then let them sit until the sediment has settled.

3. Compare the grain size in each jar. Which sediment has the smallest sized particles? The largest particles? Why?

TOPIC III: ANIMALS LIVING IN THE SEDIMENT

Soft bottoms tend to shift and do not offer a stable surface for animals that live there. In fishponds, bottom life is generally limited to species with lifestyles adjusted to cope with the problems of living in a shifting environment. Most of these animals burrow under the surface. Here they are not directly exposed to changes in the outside environment the way that surface dwellers would be. To the casual observer, the soft bottom of a fishpond may appear barren and lifeless. However, sifting of the bottom will often reveal an abundance of small burrowing animals.

Activity 3-1

ANIMALS IN THE SEDIMENT

Objective: To observe animals that live in the sediment of a fishpond.

Materials:

Large sieve made of window screen or wire mesh
Bucket or dishpans to place animals in

Procedure:

1. Sieve silt and sand scooped from the bottom through the screen. The screen will retain shrimp and other burrowing forms of life.

2. Sample other areas of the pond noting the bottom characteristics, number and types of animals found in each of the selected sites. Identify the preferred bottom habitats of the more common animals collected.

3. Compare the abundance of animals found on the reef flat to those animals found on the bottom of the fishpond. A small area of soft bottom on the shallow reef outside the fishpond can be dug out using the technique described above.

4. See Appendix A for illustrations of common sediment-dwelling animals. Most of the small shrimps and goby compete with each other and with mullet and milkfish for the same food source--the thick mat of microscopic seaweeds or diatoms attached to the bottom. Considerable numbers of animals enter the pond through water gates as very small forms, while pond walls keep out the larger ones. Therefore, if you wished to raise mullet commercially in Ali'i Pond, the competitors may need to be reduced or eliminated. How might this best be done?

TOPIC IV: FISHPOND PREDATORS

The greatest yield of harvested food from fishponds is from grazing fishes, such as mullet and milkfish, which consume plants at the base of the food pyramid. Mullet and milkfish do not distinguish living plants from decaying matter, so their stomachs invariably contain large quantities of bottom muck, as well as small forms of algae.

In spite of the intent of fishpond operators to raise plant-eating species, the pond often contains predators which may consume juveniles of valuable food species. Pond walls are an effective barrier at keeping out predators roving the reef flat. However, large predators inside the pond all entered through the screen water gates as very young small forms. Pond carnivores generally prey on the most abundant and slowest forms of pond life, which are easiest to catch. Under present conditions, because of the high density of the small goby, Oxyurichthys lonchotus, predators do not seriously affect mullet populations. Because it competes directly with mullet for the same food resource, removal of the gobies may be desirable (see Topic III). However, if the goby population is reduced, the predators will likely prey on more mullet since they would then be the most abundant fish in the pond.

The large variety of pond predators (at least 14 species) can be investigated during a field trip to Ali'i Pond. Common species are illustrated in the Appendix A.

Activity 4-1

PREDATORY ANIMALS

Objective: To observe the various types of predatory animals in the fishponds.

Materials:

Two handled 'opae nets
Buckets or plastic tubs to put fish after they are caught
Crab nets with bait and float lines
Bait (Aku heads are good)

Procedure:

1. Hold the 'opae net with two hands and push along in front of you. As you push along the bottom, the poles on each side of the net can be used to direct fish or 'opae into the net. Lift the bottom of the net first as you remove it from the water. (Fig. 6)

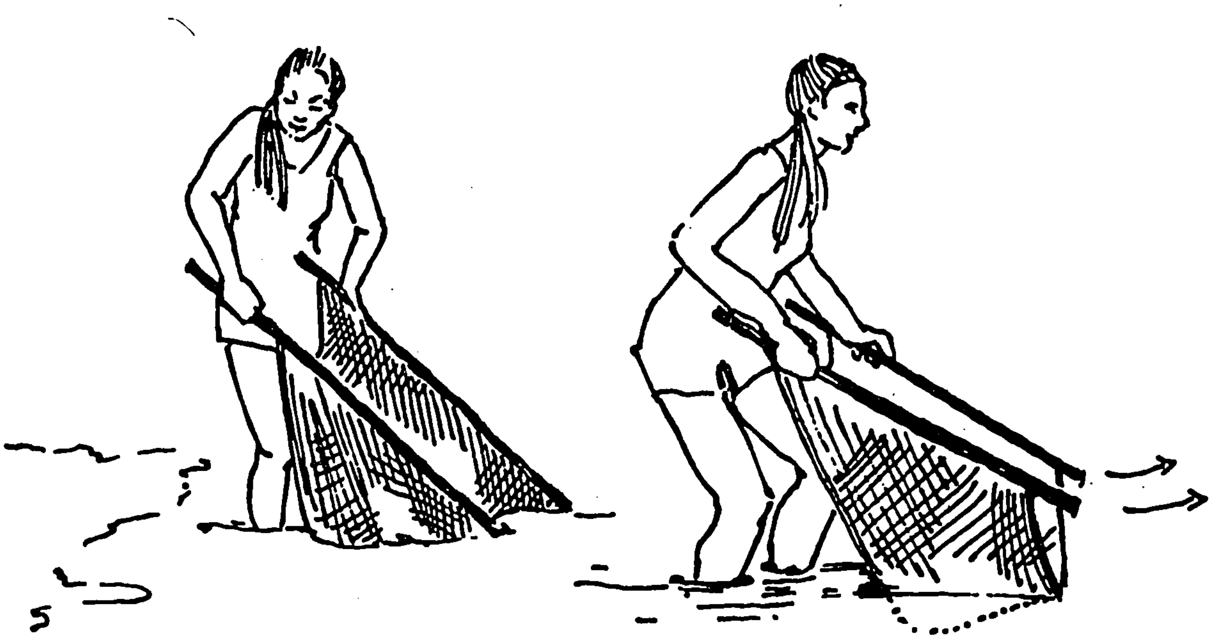

Fig. 6

2. Tie the bait in the center of the crab net. Tie a white or brightly colored float to the line attached to the bridle allowing you to locate the trap after it is set. Set crab nets in various parts of the pond. (Fig. 7)

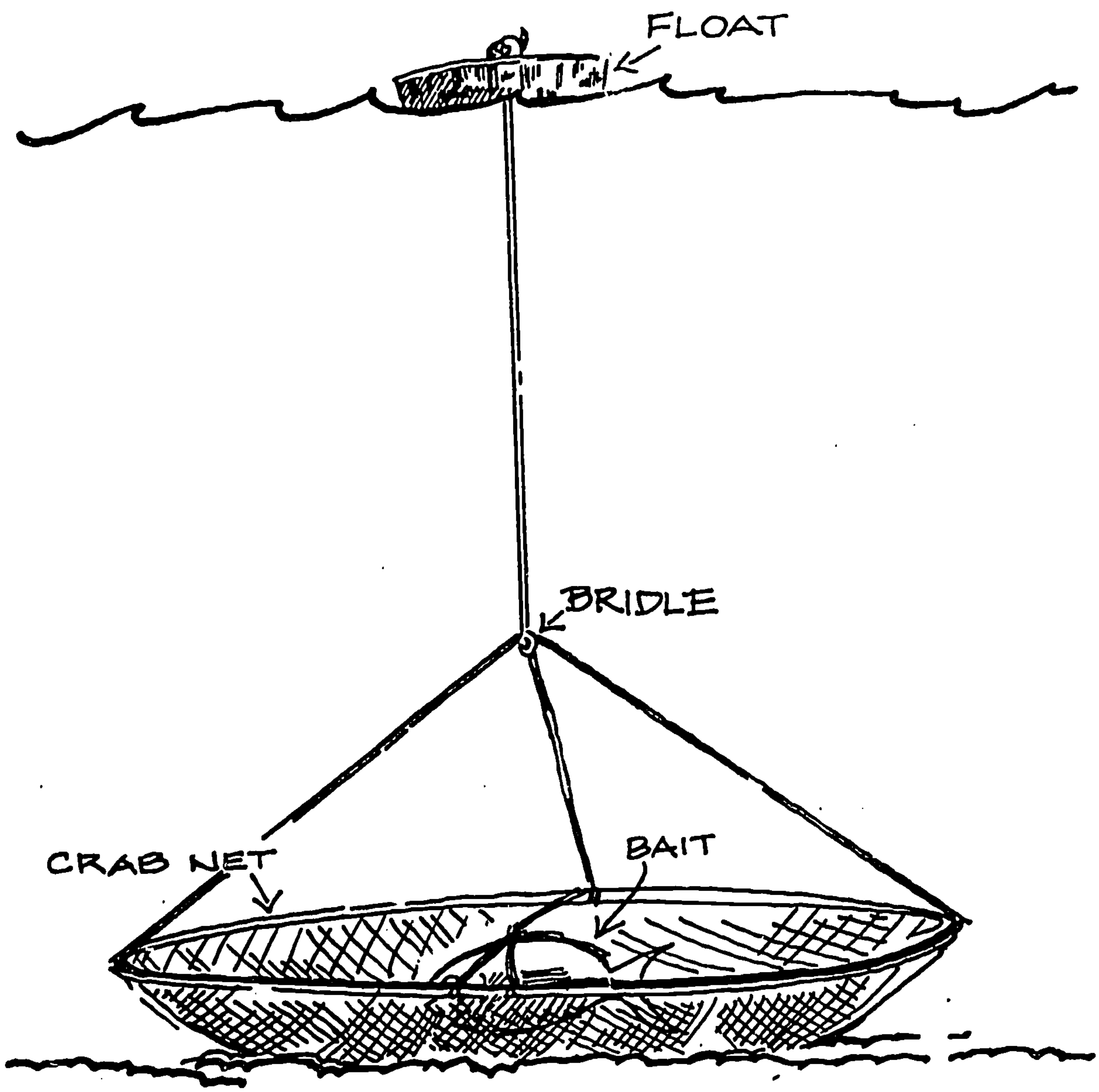

Fig. 7

Questions:

1. How might you best control the predators and increase the yields of mullet in the pond?

2. What would make seining a difficult activity in most areas of Ali'i Pond?

3. How might you explain the presence of predatory species in Ali'i Pond?

4. Would Ali'i Pond be a good commercial venture for raising mullets? Explain.

TOPIC V: MANGROVES

The mangrove tree or Kukuna-o-ka-la (Rhizopora mangle) was introduced to Hawai'i around 1900. Its extensive root system thrives in brackish water. Mangroves have overgrown large portions of many fishponds along the southeastern shoreline of Moloka'i.

Mangroves spread by rooting on shallow-water sediment deposits. Mangrove roots anchor the sediment and act as obstructions to water movement. This decrease in water movement allows for further siltation of the bottom. Thus, the water area of Ali'i Pond has been reduced by nearly 30% by the growth of mangroves. Mangroves may also be responsible for raising the salinity of the Pond as the silt and sediment clog the shoreline springs.

The extensive mangrove thicket around the northern and eastern margins of the fishpond can be explored during a field trip. Following the field trip, classroom discussion may focus on the need to remove or control mangroves to restore Ali'i Pond to operating condition. Methods of control include cutting, burning, and poisoning with herbicides. Young mangroves may also be uprooted by pulling them up by hand or mechanically using a winch mounted on a raft or onshore.

The following field trip activities focus on the propagation and spread of mangroves.

Activity 5-1

SALINITY

Objective: To measure the salinity of the water in various parts of the pond, and to relate this to the distribution of mangrove trees.

Procedure:

1. Refer to Appendix G in the "Estuary" section of Kaua'i: Streams and Estuaries.
2. Measure salinity at various places and at various water levels inside and outside the pond.

Question:

1. Does the salinity vary? Do you think the distribution of mangroves is related to salinity?

Activity 5-2

MANGROVE SEEDS

Objective: To collect mangrove seeds of various ages.

Procedure:

The immature mangrove seeds can be easily located on the mangrove trees while the mature seeds can be found floating throughout the pond. This elongated seed is buoyant and has a waxy covering which protects the germinal tissues from dessication (drying out) and high salinities. When mature, the fallen seed floats like a spar-buoy 7/8 of its length below the surface of the water. When the seed drifts into shallow water, rooting occurs in the soft mud which anchors the plant to the bottom. Stems and leaves then begin to grow.

Activity 5-3

ROOTING OF MANGROVE SEEDS

Objective: To determine which sediment and which salinity mangroves root best in.

Materials:

Various types of sediments (mud, silt, sand in different glass jars)
3.5% salt solution (salinity of 35 parts per thousand)
2.0% salt solution (salinity of 20 parts per thousand)
0 to .5% salt solution (salinity of 0 to 5 parts per thousand)
6 one gallon sized jars per team (large mouth jars)

Procedure:

1. Fill three one gallon jars 1/4 full respectively with mud, silt, and sand.

2. Carefully pour the 2.0% salt solution into each of the one gallon jars up to a level of 3/4 full.

3. Place three mature mangrove seeds into each of the one gallons jars.

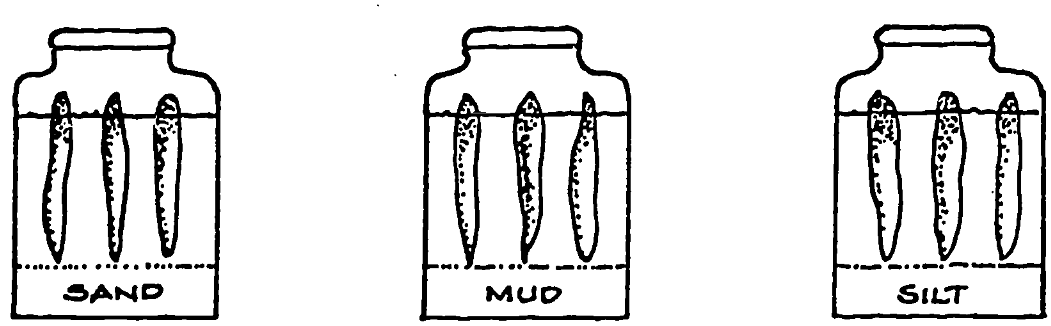

Fig. 8

4. Take the remaining one gallon jars and fill them 1/4 full with mud. (Fig. 9).

5. Fill the gallon jars 3/4 full respectively with the 3.5%, 2.0% and the 0 to .5% salt solutions.

6. Place three mature mangrove seeds into each of the remaining one gallon jars.

7. Record your observations on both sets of jars for a period of two weeks.

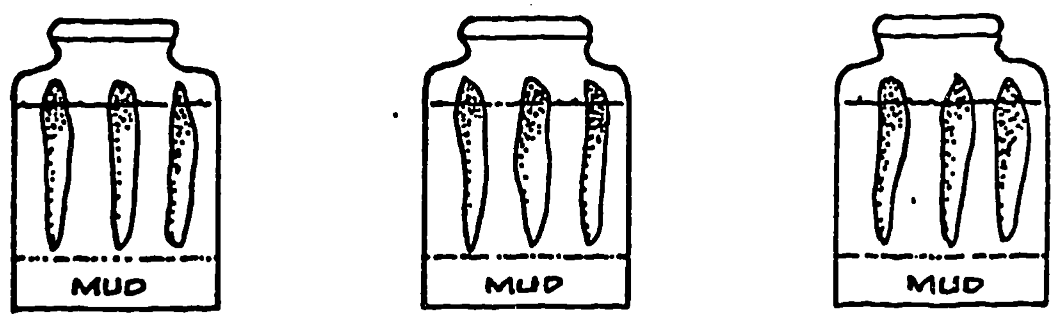

Fig. 9

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TOPIC VI: MULLET

Although early Hawaiians ate nearly all the kinds of fishes trapped or raised in fishponds, the gray mullet, or 'ama'ama (Mugil cephalus) was the principal fish farmed in the fishponds. Even in modern times, mullet have continued to be the preferred fish raised in fishponds.

Mullet had been raised commercially in one Moloka'i fishpond in recent years, though not on a regular basis. Gene Duvauchelle, Inc. leases Ni'au-pala Pond (owned by Mary Jones and L. Castor) at Ka-lua-'aha. If permission can be obtained from the owners and the leesee, class visits may be arranged at times when mullet are being netted for sale to commercial fish markets.

Activity 6-1

FISH FEEDING ADAPTIONS

Objective: To compare the feeding adaptions of two closely related fish, the mullet and the barracuda.

Materials:

Mullets
Barracudas
Scalpels for dissecting the fish

Procedure:

1. Take one of each type of fish.
2. Examine and measure the size of the mouth, lips, and teeth in each type of fish.
3. Using the following diagram, cut away the gill cover to expose the gills.

4. Determine the number of gill rakers in each type of fish.
5. Cut open the belly of the fishes as though you were going to clean it. Try not to puncture the intestines.
6. Compare and note the length of the intestine in each of the two fish.
7. Examine the contents of the stomach and intestine of the two fish.

Questions:

1. Even though the mullet and barracuda are close relatives, how might you account for the differences you've seen in the two fish?

2. What organisms might be included in a food chain for a mullet and for a barracuda?

3. What function do the gill rakers serve in a fish?

4. What might be the relationship between the length of the intestine and the type of food the fish might eat?

Teacher notes:

1. Barracuda have a larger mouth; they are primarily carnivores eating other fish. Mullet scrape detritus and algae from the rocks.

2. Barracuda have large teeth for catching prey. Apparently teeth are not necessary for mullets who are primarily algae and detritus feeders.

3. In terms of the mouth parts, the mullet's top jaw can be extended downward and they have soft, flexible lips as aids in scraping.

4. The mullet has many fine gillrakers to aid in trapping food that might otherwise be lost through the gill opening.

Activity 6-2

COOKING MULLET

Objective: To prepare mullet for eating.

Materials:

Stove, frying pan, or wok
Eating utensils
For other needs, see recipes that follow

Procedure:

SELECTION OF MULLET

Select commercially available mullet for eating using the following guidelines:

a. The fish should smell fresh, not fishy.
b. The flesh should be firm and elastic.
c. The eyeballs should be black and shiny.
d. The scales should be bright and glistening and should cling to the skin.

STEAMED MULLET

1. Clean and scale mullet. Let dry.

2. Chop up 1 tbsp. of chung choi (salted cabbage) into fine pieces.

3. Mash 1 tbsp. of dau see (Chinese black beans).

4. Mix the following ingredients with a little shoyu:

   Chung Choi
   Dau see
   1 clove of garlic
   1 tbsp. cornstartch
   1 tbsp. brown sugar
   1/2 tsp. salt
   1 tsp. vegetable oil
   1 tsp. of finely cut ginger

5. Cut grooves in sides of mullet and rub in above mixture. Also rub into body cavity.

6. Mince two green onions and rub into body cavity and grooves of the fish.

7. Arrange fish in a steamer pot above water and steam for 20-25 minutes.

FRIED MULLET

1. Clean and scale mullet.

2. Fry the fish in vegetable oil until half done.

3. Soak one cube of refried bean curd in 2-4 tbsp. of vinegar and a little water.

4. Crush two cloves of garlic, chop up 4 tomatoes, and finely chop 2 small pieces of fresh ginger.

5. Saute the garlic, tomatoes, and ginger, and add the bean curd-vinegar-water mixture.

6. Add the mullet and a little water and cook for a few minutes.

BROILED MULLET

1. Clean and scale a large mullet (1-2 pounds). Cut along the back of the mullet with a sharp knife to remove the backbone.

2. Chop up 1 onion and 2 tomatoes, salt and pepper to taste.

3. Place the onion-tomato mixture into the mullet, wrap in a banana leaf, and broil.

TOPIC VII: FISHPOND CONSTRUCTION

Coastal fishpond construction in Hawai'i was based on the materials that were present locally. The gates were made of wood. Lava and reef rock or coral were used for the walls. Most of the walls were a mixture of the two elements, with the lava rock as the major constituent. The coral rock strengthened and stabilized the walls, because the living coral and coralline algae contained in them grew over the boulders forming a natural cement.

Ali'i Pond, like most of the ponds on Moloka'i, is a loko kaupa. This type of pond was formed by building a semicircular wall of lava and coral rock from shore to shore on the shallow reef flat. In the case of Ali'i Pond, approximately 26 acres were enclosed. Other ponds along the Moloka'i coast, such as Kaloko'eli, Keawanui, Ualapue and Niaupala are similar, but vary in enclosed area. Because of tsunami and wave action, pond walls required constant repair and rebuilding. Thus the wall at Ali'i Pond has been rebuilt many times and no one knows what the original dimensions were. However, it is likely that they were similar to the present outer wall. One pond, Niaupala, was originally twice its present size, because the subsequent construction of the wall was more shoreward. This is evidenced on the reef as seen from the air. It is possible that the pond was rebuilt after a tsunami.

The present outer wall of Ali'i Pond is about 4 to 5 feet high and 4 feet wide. The wall is loosely laid, which allows water to pass through the cracks and crevices. This helps to maintain water circulation in the pond and still retain the fish. It also serves to reduce wave energy, and thus it preserves the wall. In 1971-72, the Oceanic Institute began to seal the pond for experiments by forming a double wall with pond sediment dumped between. This reconstruction was never completed and the original wall can be seen along the seaward portion of the pond.

Makaha, or water gates, were built into most, but not all, Hawaiian fishponds. Some ponds having sufficient water circulation through the loosely laid walls were built without gates. Most ponds, however, had at least one opening in the wall through which water and fish could pass. Fixed or non-moveable gates were the only types used before the arrival of the Europeans. These were made of tightly bound poles of 'ohi'a-lehua anchored to the wall at each side of the opening. Small and juvenile fishes could pass through readily but were prevented from escaping as they grew to harvestable size. After the middle of the 19th century, moveable gates combining metals and wood were used, and eventually complex double-gate systems evolved. These later devices permitted the trapping and harvesting of fishes in the makaha.

Harvesting in the old days was usually by net or by traps placed at the gate. As the tide flooded the shoreline, water flow was intensified through the narrow passage of the gate. Adult fishes, responding to this flow, moved into the current and were more easily captured. Seine and gill nets were also dragged through the pond to harvest the fish.

Makahas at Ali'i Pond have been modified over the years. Originally, only one gate was present. A second gate was constructed by the Oceanic Institute in 1966 to aid in water exchange and to reduce the silt load. Both gates have slotted concrete side posts in which wood and wire screen gates can be raised or lowered. (Fig. 10).

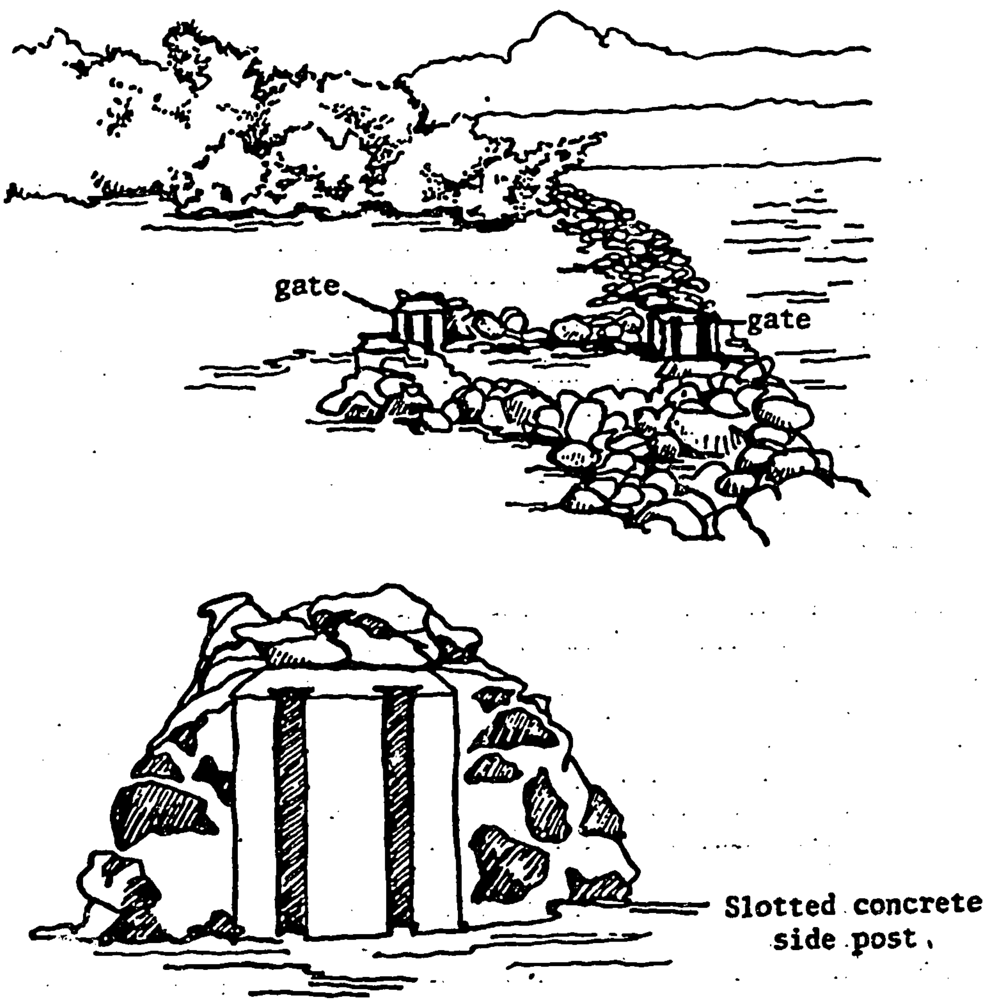

Fig. 10

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Activity 7-1

VOLUME OF POND WALL

Objective: To calculate the volume of material needed to build the original wall.

Procedure:

1. Measure the average height and width of the wall. Measurements should be taken at three different locations along the wall.
2. Multiply average height and width by 2,700 feet (the length of the wall).
3. Convert this to cubic yards (27 cu. ft. = 1 cu. yd.).
4. Calculate the number of wheelbarrow loads of stones it would require to build the wall. A large contractor's wheelbarrow holds 1/3 cubic yards.

Activity 7-2

COMPARING FISHPOND WALLS

Objective: To compare the walls of various fishponds and discuss changes that have been impacted on these pond walls.

Procedure:

1. Compare the wall construction of Kaloko'eli, Niaupapa and Ali'i Ponds to the wall construction of Keawanui Pond.
2. Which of the wall construction methods required the most work.
3. Compare the size and number of makaha or water gates at each pond.

Questions:

1. Based on wall construction, what differences might there be in water movement among the ponds?
2. Do ponds with solid walls require larger or more numerous gates?

Activity 7-3

MEASURING WATER VOLUME

Objective: To measure the amount of water passing through the gates as a factor affecting the population of a fishpond.

Materials:

Meter or Yard Stick per team
Cork or bottle half filled with water
Watch with second hand

Procedure:

1. Place the meter or yard stick at the surface along the side of the makaha.

2. Drop the cork or bottle upstream of the meter or yard stick in the center of the flow.

3. Measure the amount of time it takes the cork or bottle to pass the length of the stick.

4. Repeat step 3 for two additional times, and average the results.

5. Express the results in meters per second or feet per second.

6. Measure the volume of water in the makaha (length x width x depth) to get cubic meters or cubic feet.

7. Multiply the volume by the rate of flow divided by 2 to get a rough estimate of the water volume flowing through the gates. The derived value is divided by 2 due to the uneven rate of water through the gate. (The water flows faster in the center than it does on the sides.)

Questions:

1. Why is water exchange in the pond important? (It brings in a fresh supply of nutrients and stabilizes temperature and salinity levels.)

2. Are there differences in water flow through the different makaha of the same pond?

3. How might the movement of water affect other variables in the pond?

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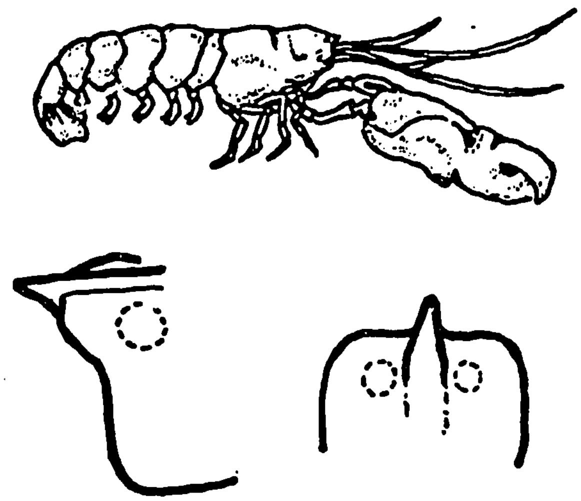
APPENDICES

IDENTIFICATION GUIDE TO COMMON FISHPOND INHABITANTS

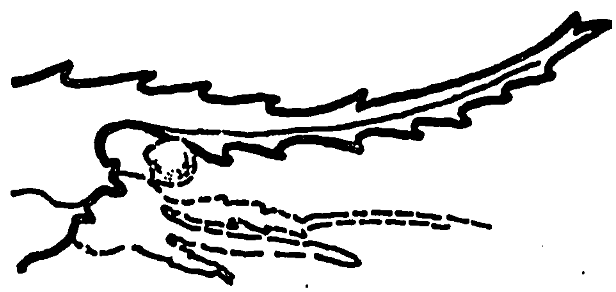
Snapping Shrimp (Alpheus lobidens)

Snapping shrimp are distinguished from other shrimp by having their eyes covered by the carapace, and by having one claw much larger than the other. They can make a snapping noise with the large claw. Alpheus lobidens has a gray-white background color and transverse bands of reddish brown to olive green on the carapace and abdomen. They live under rocks. (20-35 mm in length.)



'Opae (Palaemon debilis)

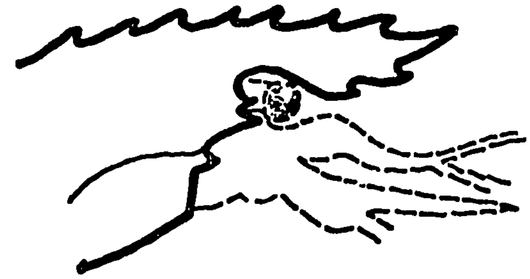
This 'opae is relatively transparent. It is easily recognized by the very long rostrum which has no spines on the terminal half of the upper (dorsal) surface. The rostrum may have 4-6 spines below. The tip is bifid (to 45 mm).



'Opae (Palaemon pacificus)

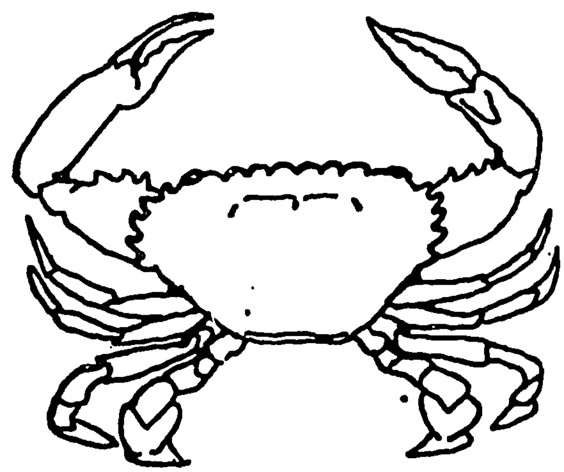
This shrimp differs from Palaemon debilis by having a shorter rostrum with 7-8 spines above and 4-5 below. The tip is obliquely trifid (to 55 mm).

'Opae (Palaemonella tennipes)

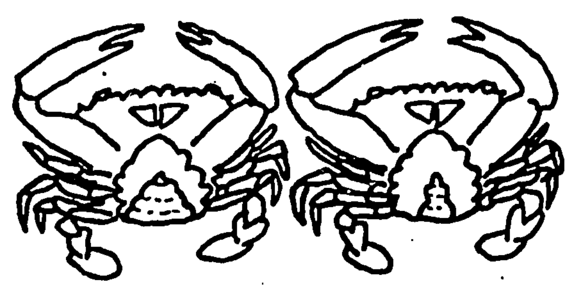


This shrimp has a shorter rostrum than either Palaemon debilis or Palaemon pacificus. There are usually 7 spines above and 2 below with no gaps between spines. The two spines on the ventral side lie directly beneath the terminal two on the dorsal side. There is also a spine on the side of the carapace.

Blue-pincer Crab (Thalamita crenata)

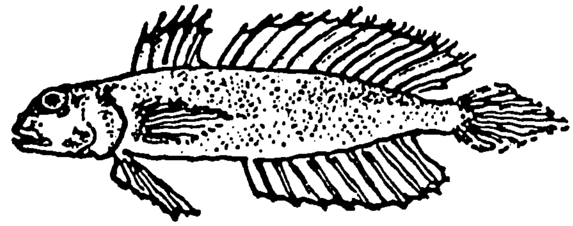


The dorsal surface is greenish brown, while the ventral side is white. The pincers are blue. There are 6 bumps between the eyes and 5 spines behind the eyes on each side. As in all "swimming" crabs, the fifth pair of legs are paddle-shaped. Males are recognized by a triangular abdomen; females have an oval abdomen.



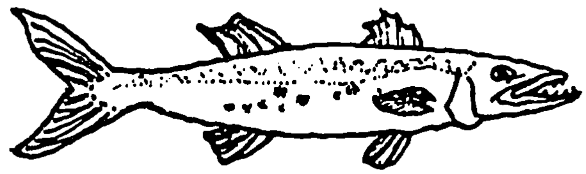
O'opu (Oxyurichthys lonchotus)

This goby is grayish white with black speckles throughout the body. It usually sits motionless on the sediment, but darts away quickly when frightened. All gobies have the pelvic fins fused into a sucking disc. (12 cm in length.)



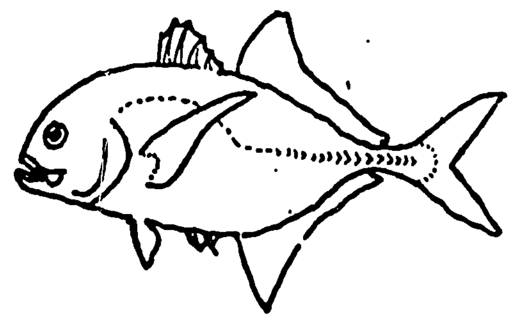
Barracuda (Sphyraena barracuda)

These fish have long, spindle shaped bodies with long heads and jaws equipped with large, sharp teeth. They are olive brown above and lighter beneath. Small specimens are found inshore. They usually hang motionless near the water surface.



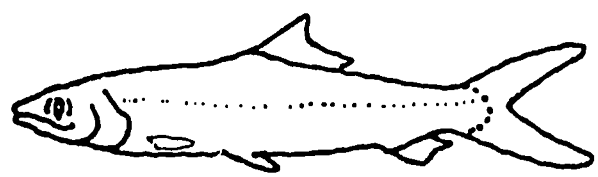
Papio (Caranx ignobilis)

The body is deep and compressed. The color is silvery. An actively swimming fish often seen in small groups.



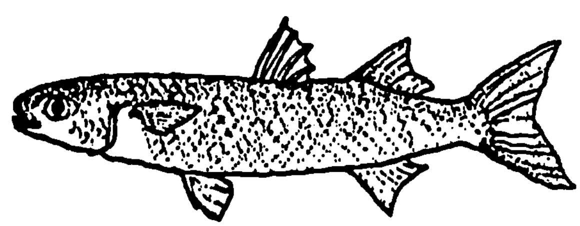
Awa'awa (Elops hawaiiensis)

A long, slender, silvery fish with a deeply forked tail and single dorsal fin. The pectoral fin is underneath rather than on the side of the body.



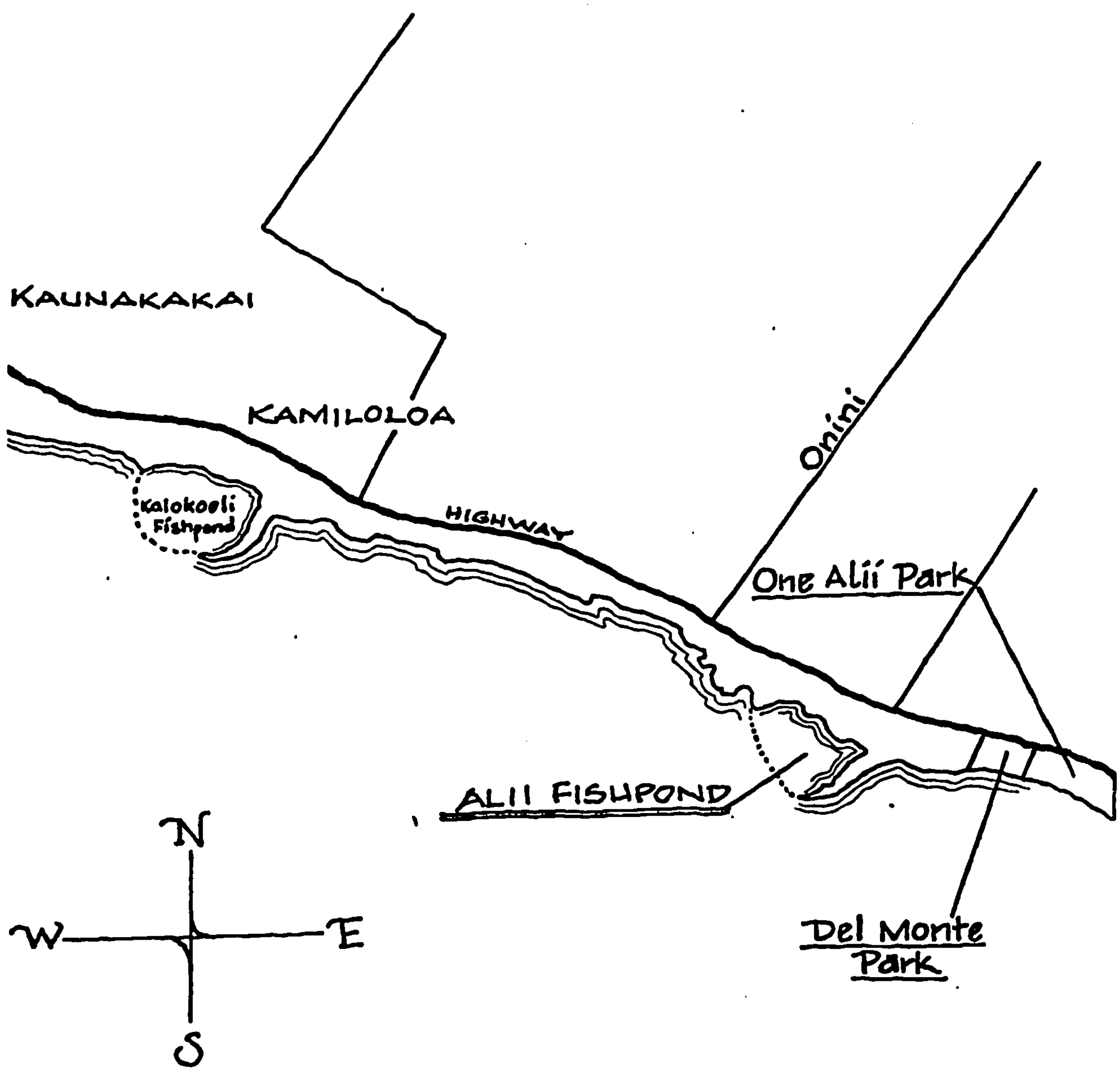
Mullet (Mugil cephalus)

A streamlined, silvery fish. Mullets do not have a deeply forked tail. Pectoral fins are on the side of the body, and there are two dorsal fins.



FIELD TRIP TO ALI'I FISHPOND

For permission to use this site, contact Hawaiian Home Lands Department, telephone 567-6104. Liability waivers will need to be signed by parents.



From Kaunakakai, drive east on Kam V highway until just before you reach One Ali'i Beach Park, about 3 miles from Kaunakakai. Look for an empty lot with coconut trees. Drive to the pond on the dirt road. Walk along the top of the fishpond wall to see the gates.

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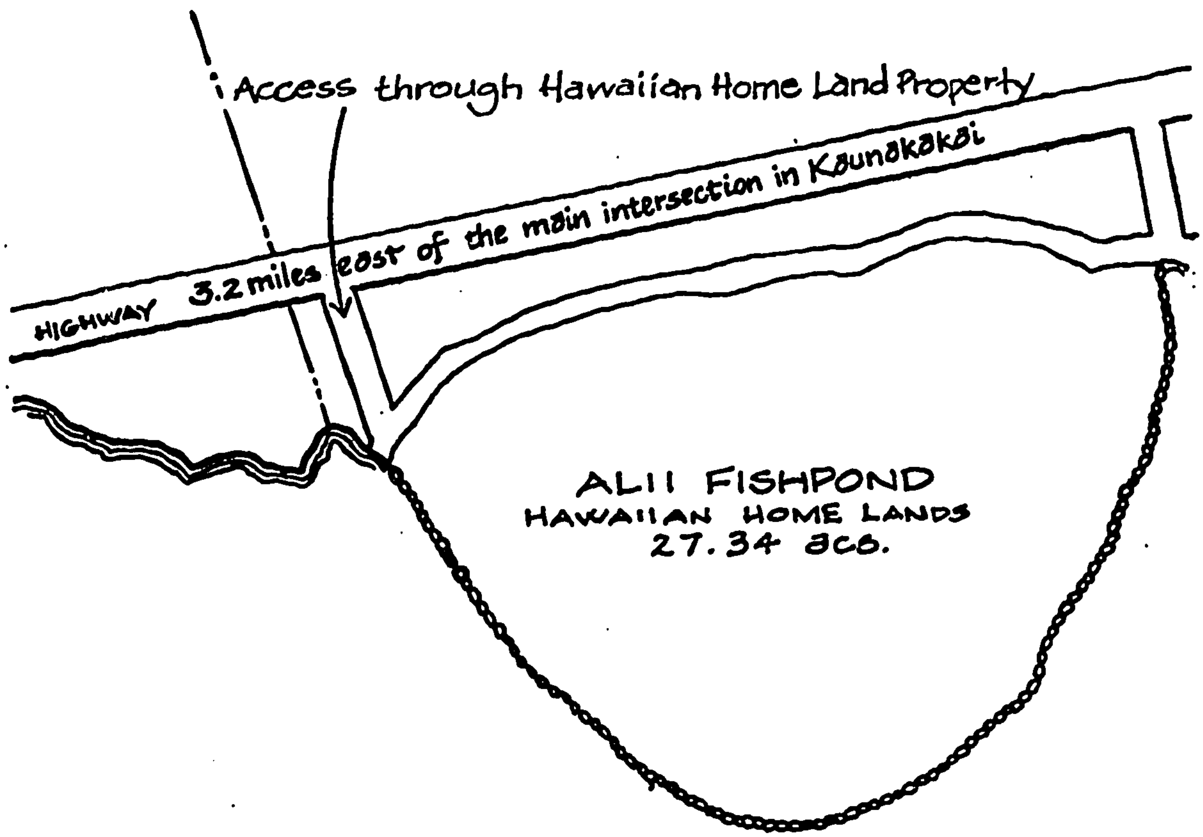

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