The Mystery of the Mostly Missing Reefs

Part 1

What is impacting coral reefs in Hilo Bay and how are human activities contributing to the problem?

Hawai'i DOE Standard Benchmarks

Science 1: The Scientific Process: SCIENTIFIC INVESTIGATION

Scientific Inquiry

- **SC.7.1.1** Design and safely conduct a scientific investigation to answer a question or test a hypothesis.

Language Arts 5: Writing: RHETORIC

Meaning

- **LA.7.5.1** Connect selected details, examples, reasons, and/or facts to the insight, message, or thesis in a meaningful way.

Activity at a Glance

Students work in teams to begin solving "The Mystery of the Mostly Missing Reefs" to determine what is affecting the health of reefs in Hilo Bay. As part of their investigation, students interview fishers and read background information.

Materials

Provided:

- ✓ Situation Report
- ✓ Sample quadrat sheet
- ✓ Evidence Data sheets 1 and 2
- ✓ Data Search Notes
- ✓ PowerPoint presentation, *The Mystery of the Mostly Missing Reefs* (provided on CD)
- ✓ Learning Log – 6
- ✓ Student Reading *The Legend of Mānaiakalani and Mokuola*

Needed:

- ✓ clipboards (one per group or have students use notebooks)
- ✓ rubber bands to secure data sheets to clipboards

For each group of 4 students:

- ✓ meter stick or tape measure
- ✓ box of colored paper clips (to use in quadrat practice)
- ✓ sheet of paper and pencil

Assessment

Students complete Learning Log - 6 with:

- hypotheses about what is affecting the growth of coral reefs in Hilo Bay, and
- the method they will use to test their hypotheses.

Key Concepts

- The primary reasons for the scarcity of coral reefs in Hilo Bay are the high volume of fresh water entering the bay through surface and groundwater sources and the breakwall, which limits the circulation of salt water entering the bay.
- Other factors that affect coral reef development in Hilo Bay include sediments and pollutants, such as nitrates and phosphates, that stimulate growth of invasive *limu*. Overfishing also impacts healthy reef development.

TIME

3 – 4 class periods

SKILLS

problem-solving, analyzing, researching

ADVANCE PREPARATION

- ☐ Make a copy of the Situation Report, Data Search Notes, Learning Log – 6, and Student Reading for each student.
- ☐ Make a copy of Evidence Data sheets 1 and 2 for students to use in the field.
- ☐ Make one copy of the sample quadrat sheet for each group of 4 students. Copy onto acetate for students to use as transparent "quadrats" in practicing the point-intercept method.
- ☐ Preview the PowerPoint presentation, *The Mystery of the Mostly Missing Reefs* (provided on CD).

VOCABULARY

abiotic - nonliving

alien species – species that are not native to an area; species introduced intentionally or accidentally to an area

biotic – living; having to do with living organisms

invasive species – species whose introduction does or is likely to cause economic or environmental harm or harm to human health

hydrology – referring to the movement, distribution, and properties of water

lōkahi – balance, harmony

nitrates – nutrients released with the decomposition of dead plants and animals and animal waste; also from sewage and fertilizer run-off

overfishing – the practice of harvesting marine life faster than it can be replenished naturally

phosphates – salts or esters of phosphoric acid; nutrients released in decomposition of organic matter and in runoff from fertilizers and sewage

point-intercept quadrat sampling – a method of sampling by placing a quadrat at regular intervals along a transect line and recording the presence of species at places where lines within the quadrat intersect

quadrat – a sampling plot used for studying plant or animal life

salinity-the total amount of dissolved material (salts) in seawater; denoted as S% or ppt (parts per thousand)

sedimentation – deposit of soil and other sediments by water

transect - a path along which one records and/or counts occurrences of the phenomenon of study for the process of estimating populations in a study area

turbidity- the amount of suspended sediments in the water; the measure of the relative clarity of the water

HAWAIʻI DOE RUBRICS

Advanced	Proficient	Partially Proficient	Novice
Science			
Consistently design and safely conduct a logical, systematic scientific investigation to answer a question and test a hypothesis	Usually design and safely conduct a scientific investigation to answer a question or test a hypothesis	Sometimes design and safely conduct a scientific investigation to answer a question or test a hypothesis	Rarely design and safely conduct a scientific investigation to answer a question or test a hypothesis

Language Arts

Thoroughly connect selected details, examples, reasons, and/or facts to the insight, message, or thesis in a creative and meaningful way	Connect selected details, examples, reasons, and/or facts to the insight, message, or thesis in a meaningful way	Connect some selected details, examples, reasons, and/or facts to the insight, message, or thesis or connect them in a superficial way	Connect few selected details, examples, reasons, and/or facts to the insight, message, or thesis or connect them in an unclear way

TEACHER BACKGROUND INFORMATION

The corals within Hilo Bay are actually very limited in number and consist of mainly "recruits"—small, visible colonies of corals. Just within the breakwall, recruits of brown and blue *Montipora sp.* and some *Porites sp.* are visible. However, they are not considered established coral reefs. The breakwall itself was constructed on Blonde Reef, a high-energy reef with various plate and encrusting corals, numerous channels and spurs (Coney, 2009).

Fresh Water and the Breakwall

A variety of hydrologic factors contribute to the relative sparsity of corals within Hilo Bay. The primary reasons for this scarcity are the high volume of fresh water entering the bay through surface and groundwater sources and the breakwall, which greatly limits circulation of salt water entering the bay. The breakwall also concentrates the fresh water in the bay. Anecdotal evidence suggests much more coral growth in the bay prior to construction of the breakwall. Wailuku River and Wailoa River along with groundwater sources, make the salinity of the bay at, or below the lower threshold required of most corals.

Coral Growth Requirements

All corals, worldwide, have relatively specific environmental requirements. Most reefs develop in waters with mean temperatures of 23-25°C. Both depth and light are important limiting factors for coral growth. The amount of light affects the ability of zooxanthellae to photosynthesize and this, in turn, reduces the coral's ability to secrete calcium carbonate—the primary constituent in coral skeletons. In general, coral development is greater in areas of strong wave action contributing to a source of fresh, oxygenated seawater.

Salinity and Sedimentation

Two other characteristics that impact coral reef growth are salinity and sedimentation, both significant factors in the Hilo Bay estuarine environment. Most corals require salinities in the range of normal seawater (32-35 ppt). Sediments contribute to turbidity of the water, reducing the light needed for photosynthesis (Nybakken, 1993). Sediments borne by surface flows also contribute to a decrease in available light for the zooxanthellae symbionts in corals. Corals such as *Montipora sp.* appear to be resilient to stresses such as sedimentation and salinity changes, hence, their appearance within the breakwall (Gulko, 1998).

Pollutants
Excess nutrients (pollutants)—such as nitrates and phosphates—from surface and groundwater sources can contribute to both macroalgal blooms impacting reefs directly, and phytoplankton blooms that, in turn, impact the turbidity of the water and subsequent coral development.

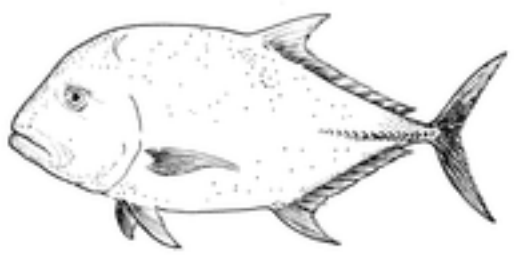
Invasive Species
Invasive algae have caused serious problems for coral reefs in Kāneʻohe and Māʻalaea bays. On Hawaiʻi Island, two species are prevalent, *Acanthophora spicifera* and *Gracilaria salicornia*. As with all invasive algal species, displacement of native *limu* and dense growth patterns can negatively affect coral growth.

In a balanced, healthy reef ecosystem, corals and coralline algae are the dominant species. The fleshy *limu* are less dominant but they play an important role at the base of the food chain, supporting the diverse species of invertebrates and herbivorous fish that feed on them. When nutrients, such as nitrates and phosphates from human sewage and lawn or golf course fertilizers, wash onto the reef, conditions are favorable for the fleshy *limu* species to grow more rapidly.

Overfishing
Another factor that contributes to the possible invasion of *limu* species is overfishing. The Department of Land and Natural Resources, Division of Aquatic Resources (DLNR/DAR) requires commercial fishers to file fish catch reports, which helps the agency to monitor the resources. DAR reports that there has been a significant decrease in the abundance of inshore marine resources over the past three decades (DLNR/DAR 2005). When herbivorous fish that help to control the growth of *limu* are overfished, this affects the balance of the coral reef. When overfishing is combined with excessive nutrients from human activities, the stage is set for problems.

Quadrat Sampling Method
Scientists studying coral reefs use the quadrat sampling method that is introduced in this "mystery" for students to solve. The method involves counting organisms or estimating percentage of area covered by organisms in plots or quadrats. These quadrats are placed along transects of appropriate size and number to get an estimate of density in the area sampled. In this investigation, we recommend that students use the point-intercept method with quadrats placed along a transect line.

Teaching Suggestions



ulua (giant trevally)

1. **Introduce the "Mystery of the Mostly Missing Reefs" to students.**
   - Present the focus question for this investigation and the standards students will be addressing.
   - Explain that there are many factors affecting the growth of reefs in Hilo Bay and that students will be working in teams to

gather clues to help them identify the suspects that may be contributing to the scarcity of coral reefs in Hilo Bay.

2. **Show the PowerPoint presentation provided with this lesson to introduce the suspects in the mystery.**
   - Divide the class into investigative teams and ask students in each team to prepare to take notes during the presentation. Explain that these notes will help the team to discuss the suspects after the presentation.
   - Pose questions during the PowerPoint presentation to help students focus.

     PowerPoint Presentation Questions

     The Mystery:
     - How do the reefs in Hilo Bay appear compared to other Big Island locations?
     - Visually, how does Hilo Bay, and its waters, compare to the other images seen?
     - How is *lōkahi* (balance, harmony) evident or not evident in the images of the reefs?

     The Suspects:
     - Which of the suspects are seen? Any look like guilty parties? Why?
     - Which are the least likely to be the cause of minimal coral populations in Hilo Bay? Why?
     - How could we find out?
     - Which biotic (living) and/or abiotic (non-living) suspects could we identify as the cause of "The Mostly Missing Reefs?"

3. **Review the assessments that will be required for each student to solve the mystery and distribute the Situation Report.**
   - Review the **Situation Report** and explain that it holds clues to the mystery.
   - Challenge teams to read the report, take notes, and discuss.
   - Summarize their ideas about clues contained in the report, particularly the possible impact of pollutants (like nitrates and phosphates) from cesspools and stream run-off into the bay.

4. **Ask students in each team to complete a first draft of Learning Log - 6 and present their thinking to the rest of the class.**
   - Have students use pencils to complete this draft so that they can update it as needed.
   - Challenge students to use any and all prior knowledge as they work on hypotheses and methodology. Encourage them to ask questions of their peers.
   - Ask teams to develop a hypothesis that addresses: a) which suspects are responsible for the missing reefs, and b) why they are responsible.
   - Have each team present its hypotheses and discuss students' ideas.

5. **Encourage teams to interview fishers and elders familiar with the bay to gather additional evidence about how the reefs are changing over time.**

- Ask teams to develop a set of questions and review them with one another before requesting interview time with family members or others in the community.
- Discuss proper ways to approach people for interviews and the importance of thanking them for their information and time.
- A polite gesture is to offer a *makana* (gift) to the interviewee. It could be something the student made or gathered from his/her *wahi* (place). This simple act honors the person who is providing the student with valuable information and opens the door to a successful interview.
- Discuss the importance of taking notes during an interview and checking to see that the information recorded was heard correctly. Students may want to ask permission to tape record the interviewee for later reference.
- Ask students to report their findings from the interviews.

6. **Distribute Evidence Data Sheet 1. Discuss ways that students could test their hypotheses at Mokuola (Coconut Island) and practice the quadrat method.**
   - Explain that scientists often use a point-intercept method with a transect line and a quadrat to study the composition of reefs. Since it isn't possible to count everything, this is one method to estimate the percent cover for different species.
   - To practice this method before going on the field trip, explain that the meter stick or tape is the transect, the transparency represents the quadrat, the desktop represents sand, and the colored paper clips represent living organisms on the reef.

Procedure for Point-Intercept Quadrat Sampling

- Divide the class into groups of four students and give each group a transparent quadrat, a meter stick or tape, and a box of colored paper clips. Ask each group to have a sheet of paper and pencil as a tally sheet.

Demonstrate for the class:

- Lay a transect line (meter tape measure or meter stick) on a cleared tabletop or floor area. Toss the different colored paper clips randomly in the area.
- Lay a quadrat transparency at the 0 point on the transect line over the colored items you have tossed.
- Ask students to record what they see touching the intersection of each of the 16 points on the quadrat, e.g., tabletop, green paper clip, blue paper clip etc.
- Have all groups set up their sample transects, paper clips and quadrats and tally what they see.
- When they have finished recording, ask all groups to move the transparent quadrat sheets to the 24-centimeter point on the transect lines and have students record what they see at each point on the quadrats.
- Continue this process at the 48- and 72-centimeter points on the transect lines and make sure everyone has had a chance to participate and practice.

7. **Practice the math procedure to calculate the percentage cover of "sand" and each different "species".**

$$\text{Percent cover} = \frac{\text{\# of "hits" for an item*}}{\text{total \# of intercept points}}$$

*"Hits" refers to the presence of an item at an intercept point

8. **Determine how effective this method was for sampling the "reef."**
   - Count the total number of colored items that were actually distributed in this practice session and have students compare this to their results.
   - Discuss the effectiveness of this method for sampling a reef and why scientists need to use sampling methods.

9. **Distribute Data Search Notes and Evidence Data Sheet 2 and review them with students.**
   - Discuss the new information being presented and how this might impact students' initial hypotheses and methods.

10. **Distribute the Student Reading, *The Legend of Mānaiakalani and Mokuola*, and review it.**
    - Assign the Student Reading and ask students to complete the reading response questions.
    - Discuss the cultural significance of Mokuola where students will be collecting their data.

11. **Have students complete a final draft Learning Log – 6 with their hypotheses, method, and summary of evidence from interviews and/or reading.**
    - Be sure they revise hypotheses and methods including information provided in Data Search Notes and Evidence Data Sheet 2.
    - Have students begin thinking of additional questions they would like to have answered in this investigation.

Adaptations / Extensions

Language Arts: Writing: Range

- Have students interview *kūpuna* about the different ways that Hawaiians used *limu* for food, medicine, adornment, and protocol. Ask them to reflect in their Learning Logs about what they learn.
- After conducting interviews with fishers and elders, have students write a summary with the writing prompt: "Back in The Day…" Have them describe the changes others have seen in Hilo Bay.

Writing Prompts

- Hawaiians use different kinds of *limu* (seaweed) to…
- Today we use *limu* for many things, including…

Science 1: Scientific Investigation - Have students conduct experiments growing *limu*. Place an invasive *limu* species such as *Gracilaria* from the bay in a tank with a non-invasive native species. Add nitrogen fertilizer to the tank over a two-week period and see which species grows more rapidly. For more information on this experiment, and other activities related to invasive

limu, see the *Investigating Limu* module produced by the U.H. Hawai'i Marine Algae Group (HIMAG) available online at: http://manoa.hawaii.edu/limu/resources.html.

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Nybakken, James. 1993. *Marine Biology, An Ecological Approach*. Harper Collins College Publishers. New York, NY.

RESOURCES

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Russell, Dennis J. 1992. *The Ecological Invasion of Hawaiian Reefs by Two Marine Red Algae, Acanthophora spicifera (Vahl) Boerg and Hypnea musciformis (Wulfen) J. Ag., and their association with two native Laurencia nidifica J. Ag. and Hypnea cervicornis*. J. Ag. ICES Marine Science Symposium 194: 110-125

WEB RESOURCES

http://apdrc.soest.hawaii.edu/Hawaii/water_quality_observations.html

http://hawaii.gov/health/environmental/water/cleanwater/WaterQualityData/prc/pdf/WatershedBasedPlanHiloBay.pdf

Sample Quadrat for Point-Intercept Practice

Make one copy onto acetate for each of group of 4 students.