The Case of the Invaded Reef
Part 1

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

Hawaiʻi 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 Case of the Invaded Reef" to determine what is invading the reefs and the factors that caused the invasion to occur. As part of their investigation, students interview fishers and read background information.

Materials
Provided:
- ✓ Crime Scene Report (includes map of Māʻalaea Bay)
- ✓ Evidence Data sheets 1 and 2
- ✓ PowerPoint presentation, *The Case of the Invaded Reefs of Māʻalaea Bay* (provided on CD)
- ✓ Learning Log - 6

Needed:
- ✓ water quality test kits
- ✓ gloves and safety goggles
- ✓ clipboards (one per group or have students use notebooks)
- ✓ rubber bands to secure papers to clipboard
- ✓ rope (cut into two 4-meter lengths to use as quadrats)
- ✓ 2 meter tape measures
- ✓ permanent marker
- ✓ old colored socks (variety of colors one pair from each student) or use color photographs of the "suspects" from the PowerPoint presentation

Assessment
Students complete Learning Log - 6 with:
- hypotheses about what is invading coral reefs in Māʻalaea Bay and the factors that contributed to the invasion, and
- the method they will use to test their hypotheses.

Key Concepts
- Coral reefs in Māʻalaea Bay are being invaded by alien and invasive native *limu* species.
- The invasion of *limu* on the coral reefs is due to a number of factors including overfishing, introduction of non-native *limu*, and pollutants from surrounding communities.

Time
3 – 4 class periods

Skills
problem-solving, analyzing, researching

Advance Preparation
- ☐ Make a copy of the Crime Scene Report and Learning Log – 6 for each student.
- ☐ Make a copy of Evidence Data sheets 1 and 2 for each team to review and use in practice sessions with the transects and water test kits.
- ☐ Preview the PowerPoint presentation, *The Case of the Invaded Reefs of Māʻalaea Bay* (provided on CD)
- ☐ For the practice transect study, ask students to each bring a pair of colored socks from home **or** make 10 copies of each "suspect" from the photographs provided in the PowerPoint presentation.

Vocabulary
alien species – species that are not native to an area; species introduced intentionally or accidentally to an area
invasive species – species whose introduction does or is likely to cause economic or environmental harm or harm to human health
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
quadrat – a sampling plot used for studying plant or animal life
sedimentation – deposit of soil and other sediments by water

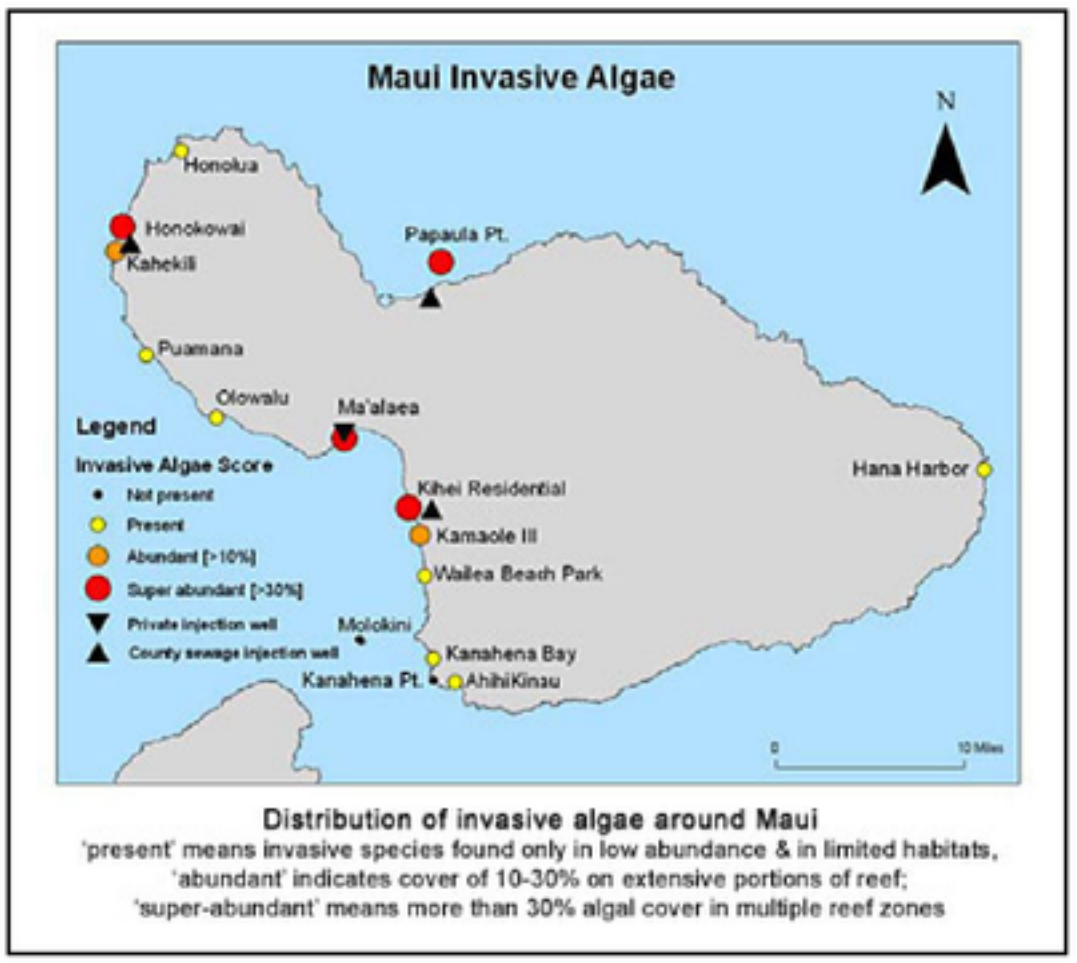
transect - a path along which one records and/or counts occurrences of the phenomenon of study for the process of estimating population entities in a study area

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 beautiful and diverse coral reefs of Māʻalaea Bay are an incredible resource that is changing. Unfortunately, the reefs are losing their diversity as invasive *limu* (algae) species overgrow the corals. As the map of invasive algae species shows, surrounding areas of Māʻalaea Bay contain "super abundant" distributions of invasive algae. These algae include prickly seaweed (*Acanthophora specifera*), hookweed (*Hypnea musciformis*), and interestingly, sea lettuce seaweed (*Ulva* spp.), a native species that has become invasive. (Note: a full-page version of this map is provided in the PowerPoint presentation for this lesson.)



Distribution of invasive algae around Maui
'present' means invasive species found only in low abundance & in limited habitats,
'abundant' indicates cover of 10-30% on extensive portions of reef;
'super-abundant' means more than 30% algal cover in multiple reef zones

Source: Russell Sparks, Dept. of Land and Natural Resources, Division of Aquatic Resources

The factors that led to this invasion can all be traced back to human activities. The student reading provided with this activity includes a history of events that contributed to the invasion of coral reefs by *limu* species.

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 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.

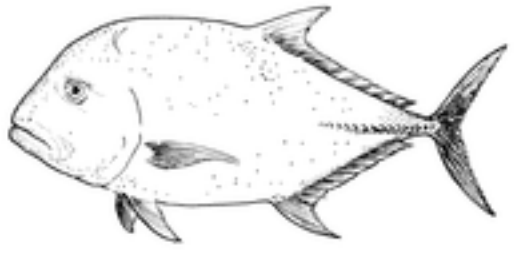
Another factor that contributes to the invasion of *limu* species is overfishing. The Department of Natural Resources, Division of Aquatic Resources (DLNR/DAR) requires commercial fishers to file fish catch reports, which helps the agency to monitor the resources. DAR reports that there has been a significant 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 on land, the stage is set for invasion.

In the early 1970s, Māʻalaea Bay was a garden of distinct and diverse types of *limu* and fish. At the time, the bay was found to be unique throughout Hawaiʻi because there were a diverse number of *limu* species which were found in greater abundance compared to other areas of the state. At least 19 *limu* species were present at the time and there was a good balance between *limu* and herbivore fishes (Kinsey, 1972). In the early 1990s an invasive *limu*, *Acanthophora specifera*, made its way to Maui and became highly invasive along Maui's shores. Particularly, the west and south shores of Maui were hit hardest. Over the next decade, other invasive *limu* such as hookweed (*Hypnea musciformis*) and sea lettuce seaweed (*Ulva* spp.) plagued Maui's shorelines (Sparks, 2007). In some areas the *limu* created mats over three feet thick! This affected not only the health of the coral reef and the abundance of marine fish, it also caused economic problems for shoreline communities.

Scientists studying invasive *limu* use the quadrat sampling method that is introduced in this "case" 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.

Teaching Suggestions

1. **Introduce the "Case of the Invaded Reef" to students.**
   - Present the focus question for this investigation and the standards students will be addressing.
   - Explain that there are invaders taking over some of the reefs in Māʻalaea Bay and that students will be working in teams to solve the mystery of the invaders' identity and piece together clues to explain **why** the invasion has taken place.



ulua (giant trevally)

2. **Show the PowerPoint presentation provided with this lesson to introduce the suspects in the case.**
   - 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 Case:
     - How did the reef look before the invasion?
     - How is it different after the invasion?
     - How is *lōkahi* (balance, harmony) evident or not evident in the images of the two reefs?

     The Suspects:
     - Which of the suspects are most likely to be the invaders? Why?
     - Which are the least likely to be invaders? Why?

- How could we find out?
- What factors allowed the invasion to occur?

3. **Review the assessments that will be required for each student to solve the case and distribute the Crime Scene Report.**
   - Review the Crime Scene 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 nitrates from sewage injection wells and stream run-off into the bay.

4. **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.

5. **Ask students in each team to develop hypotheses about the case and present them to the class for discussion.**
   - Ask teams to develop two hypotheses: a) who the invaders are, and b) what allowed the invasion to take place.
   - Have each team present its hypotheses and discuss students' ideas.

6. **Discuss ways that students could test their hypotheses at Kōʻieʻie Fishpond and practice the quadrat method.**
   - Explain the quadrat method that scientists often use to study the composition of reefs.
   - Practice the quadrat method that students can use to determine which species are dominant at Kōʻieʻie Fishpond.

<u>Procedure</u>

- If students are using socks to represent organisms, have students fold their pairs of socks together to make clumps that can be scattered around the transects. Place the socks (or photos of suspects) into a bag.
- Lay the transect lines (meter tape measures) out in a cleared area (in the classroom or hallway on the school grounds). Toss the different colored sock clumps randomly in the area (or place colored suspect photos, picture side up in the area).
- Use the 4-meter rope sections to form a square (quadrat) next to each transect line at one end of it.
- Form two groups, one to work on each transect line. Have students estimate the percent of area covered by each different colored sock (or photo) in the quadrat and record the amounts. (It helps to mentally divide the area within the quadrat into quarters, and visually estimate how much space an "organism" is covering.)
- Move the quadrats two meters farther along the transects and repeat the sampling procedures with different students estimating percent covered by the different colored socks. Repeat the procedure until everyone has had a chance to participate.

7. **Practice the math procedure to calculate the abundance of each different "sock" suspect.**
   - The area studied would be the total number of square meters sampled.

$$\text{Abundance} = \frac{\text{total \% of area covered}}{\text{area}}$$

8. **Discuss ways to test water quality.**
   - Distribute Evidence Data sheet 2 and review it with students.
   - If you have nitrate test kits, you may want to have students practice using them before the field investigation, although this is not necessary as the kits are easy to use.

9. **Have students complete Learning Log – 6 with their hypotheses, method, and summary of evidence from interviews and/or reading.**

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.

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 *Hypnea* 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) included in this field test packet.

References

Alien and Invasive Algae in Hawai'i. 2000. Hawai'i Coral Reef Initiative Research Program. University of Hawai'i at Mānoa, Department of Botany. Retrieved June 2, 2005, from http://www.botany.hawaii.edu/GradStud/smith/websites/Alien-Summary.htm (Have students select Marine Plant Research, Hawai'i Coral Reef Initiative, to view information on the invasive algal species pages.)

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