THE CASE OF THE INVADED REEF

Part 1

What is invading coral reefs in Kāneʻohe 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 Kāneʻohe Bay)
- ✓ Evidence Data sheets 1 and 2
- ✓ PowerPoint presentation, *The Case of the Invaded Reefs* (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 Kāneʻohe Bay and the factors that contributed to the invasion, and
- the method they will use to test their hypotheses.

KEY CONCEPTS

- Coral reefs in Kāneʻohe 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 Reef* (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

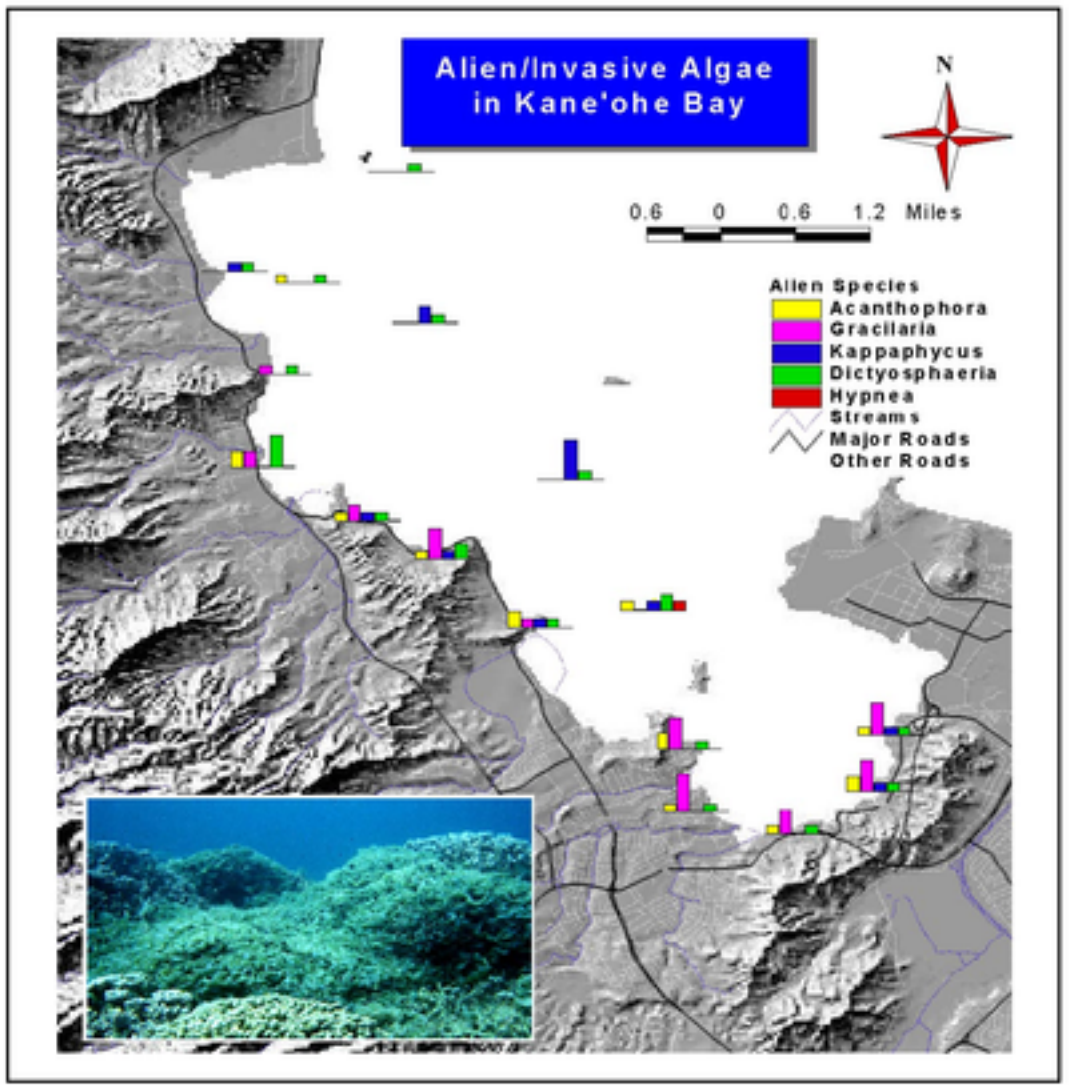
Teacher Background Information

The beautiful and diverse coral reefs of Kāneʻohe 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 alien/invasive algae species shows, *Gracilaria salicornia,* also known as "gorilla ogo" is one of the most successful invaders in the bay. Interestingly, *Dictyosphaeria cavernosa,* commonly known as green bubble algae, is a native species that has become invasive.

The factors that led to this invasion can all be traced back to human activities. The student reading provided with this activity includes a chronology 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.



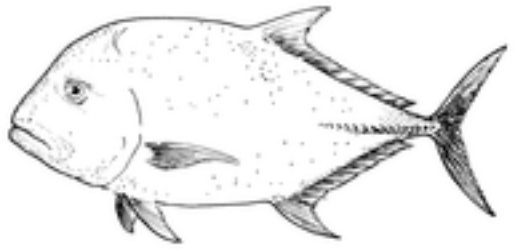
Source: Jennifer Smith, PhD., University of Hawaiʻi at Mānoa

Since 1950, there have been 18 different species of *limu* introduced to Oʻahu, some intentionally for aquaculture research, and others accidentally on ship hulls (Russell, 1992). Five of those species have become highly invasive, including those on the map on the previous page (with the exception of the native species *Dictyosphaeria cavernosa).*

Some researchers speculate that the bubbles or caverns in this native *limu* species may store nutrients that allow this species to grow rapidly and become invasive.

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



ulua (giant trevally)

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 Kāneʻohe 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.

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.

     <u>PowerPoint Presentation Questions</u>

     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.

green bubble algae
(native to Kāne'ohe Bay)

6. Discuss ways that students could test their hypotheses at Moku o Loʻe (Coconut Island) 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 Kō'ie'ie 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.

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).

Writing Prompts

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

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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Kamakau, Samuel M. 1991. *Tales and Traditions of the People of Old: Nā Moʻolelo a ka Poʻe Kahiko*. Bishop Museum Press. Honolulu, HI.

Kawaharada, Dennis. © 1999-2006. Kapi'olani Community College. *Traditions of Oʻahu: Stories of an Ancient Island*. Retrieved May 20, 2005 from
http://apdl.kcc.hawaii.edu/~oahu/stories/koolaupoko/chiefs.htm
This website, developed by Dennis Kawaharada, provides legends, site maps, the names of winds, rains, the *ahupuaʻa*, and general information about the island of Oʻahu.

Pukui, M.K. and Elbert, S.H. 1986. *Hawaiian Dictionary*. Revised and Enlarged Edition. University of Hawai'i Press. Honolulu, HI.

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.

THE CASE OF THE INVADED REEF — EVIDENCE DATA SHEET 1

TEAM NAME: _____ **DATE:** _____

- Lay out the transect line in the area of the scene of the invaded reef. Have members of your team hold each end of the rope.
- Place the quadrat in the water at the beginning of the transect line.
- Use the species identification cards to identify suspects and record all species that you find within the quadrat. If you are unable to identify a species, make a detailed sketch and give it a name.
- 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.

Sample Area	Species Found		Percent Cover (For each species)	
1				
2				
3				
4				
5				

(Notes: On the other side of this sheet record your observations of the invaded reef.)

THE CASE OF THE INVADED REEF — EVIDENCE DATA SHEET 2

We will be measuring the concentration of nitrogen (in the form of nitrates) in the near shore water. The concentration is measured in mg/L, which is equivalent to parts per million (ppm). Nitrates are important for living organisms to make proteins. Although important to living organisms, if nitrate levels are too high, this can upset the natural balance of life on the reef. The Environmental Protection Agency has set standards for the amounts of nitrate in the environment. Kāneʻohe Bay is classified as Class A pristine waters with a standard for nitrates ranging between 0.08 mg/L (wet season) to 0.05 mg/L (dry season) (*Chapter 54 of Title 11 of the Hawaiʻi Administrative Rules*).

Method: Collect seawater samples from two sites along each transect line. Collect seawater at the beginning of each transect and at the end.

- Follow the directions on the nitrate test kits. Use gloves and safety goggles when handling the chemicals in the test kits. Record your results below:

Data:

Transect 1	Site 1: Nitrates in mg/L	Site 2: Nitrates in mg/L
Transect 2	Site 1: Nitrates in mg/L	Site 2: Nitrates in mg/L

- Compute the average value for the four sites. What can you conclude from this data? How does it relate to the Case of the Invaded Reef?

1. If there is no evidence of nitrates at Moku o Loʻe (Coconut Island), can we assume that we would get similar measures at other areas in Kāneʻohe Bay? Why or why not?

2. Where would you expect nitrate levels to be higher?

3. What conditions might contribute to higher nitrate levels at different times?

Note: Nitrate is the end result of the conversion by the nitrifying bacteria Nitrobacter and is considered to be relatively non-toxic to fish. However, if nitrates are continually present in an over abundant amount, fish will die. Nitrates become toxic to fish (and plants) at levels of 50-300 ppm, depending on the fish species. For young fish, much lower concentrations become toxic and nitrate levels should not exceed 40 ppm.

THE CASE OF THE INVADED REEF

LEARNING LOG - 6

INVESTIGATOR'S NAME: _____ **DATE:** _____

Your task:

- Find out who the invaders are!
- Gather evidence of what allowed this invasion to occur.

Hypothesis 1: Write your hypothesis about who the invaders are.

Hypothesis 2: Write your hypothesis about conditions that allowed the invasion to happen.

Method: Describe the method you will use to solve the case.

Summary of Evidence Gathered: Interviews: Summarize key points from interviews.

THE CASE OF THE INVADED REEF — CRIME SCENE REPORT

PRELIMINARY INVESTIGATOR: Dr. Pheelay O'Pheesh, Marine Biologist

LOCATION: Fringing Reefs – Kāneʻohe Bay, Moku o Loʻe (Coconut Island; see map provided)

CRIME SCENE: Corals were found smothered and killed. Evidence gathered shows invasion most severe on fringing reefs, particularly in southern end of the bay. The reef around Moku o Loʻe (Coconut Island) is also invaded. Fish were absent. There was evidence of sediment from land in ocean, covering some corals. Map shows fringing reefs close to shore, barrier reef farther out in the bay, and smaller patch reefs in quiet waters of lagoon.

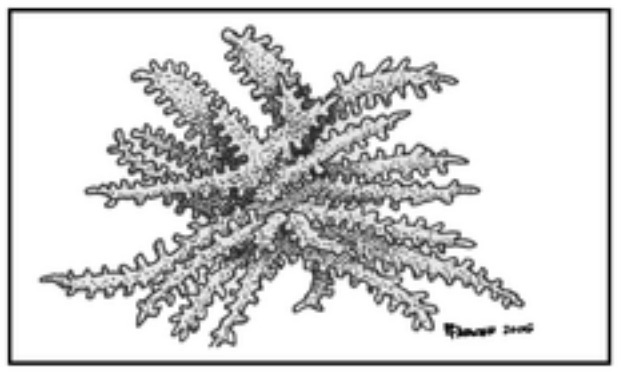
INVESTIGATOR'S NOTES: HISTORY OF KĀNEʻOHE BAY:

Early Hawaiians raised fish in 23 different fishponds constructed along shoreline of bay. The large sandbar, Ahu O Laka (Altar of Laka) was called Ahu A Laka (Sand Bank of Laka) in ancient times. It was named after a chief named Laka whose final wish was to die on its sandy shoal. The first written descriptions of the bay in late 1800s describe a crystal clear lagoon with abundant corals and reef fishes and clean white sand beaches surrounding the bay. Streams flowed into the bay's fishponds and through many *loʻi kalo* (taro patches) that Hawaiians built to grow their staple food crop.

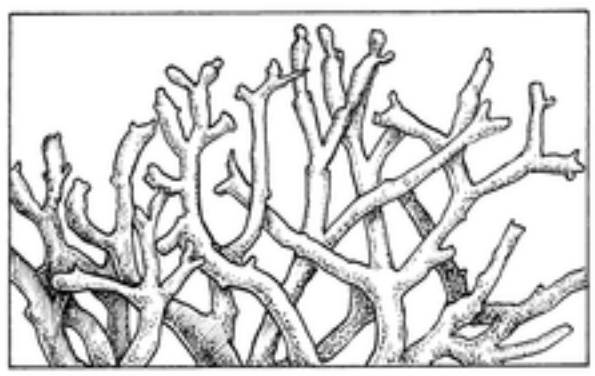
KEY EVENTS:

- 1940 - Sugar and pineapple plantations left exposed soil that washed into bay during heavy rains.
- 1950 - Sewage outfall constructed in the southern part of bay. Dumping of untreated sewage into the water
- 1968 - Surveys of bay show fewer species in south lagoon. Species thriving on nutrients from sewage are abundant in middle lagoon.
- 1970 - Some streams diverted into cement channels to control flooding. During heavy rainfall, run-off of soil and nutrients such as nitrates and phosphates into bay increased.
- 1977 - Sewage dumping into Kāneʻohe Bay stopped and diverted to offshore of Mōkapu Point.
- Hills around Heʻeia severely eroded by cattle, causing more sedimentation on reef as soil and nitrates wash into the bay.
- Human population growth in the area increased to more than 47,000 people. Land cleared for houses and roads, causing more sedimentation.
- 1990s - Fish harvest from bay declined.

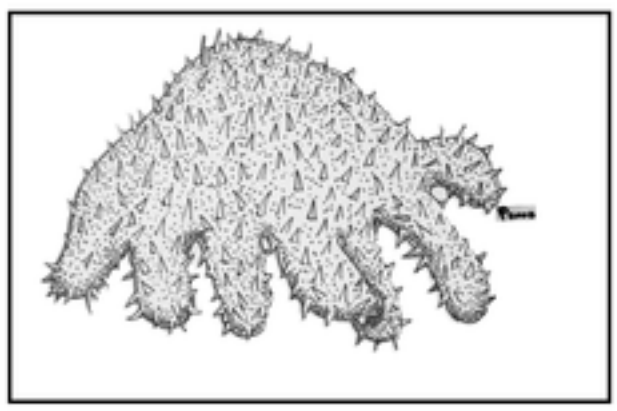
SUSPECTS: All of the following species are suspected invaders!



1 Smothering seaweed *(Kappaphycus spp.)* Suspect first sited in Kāneʻohe Bay in 1970. According to initial reports this alleged-perpetrator has NOT spread to other islands. Suspect has reputation for growing in mound-like mats that smother its victims.



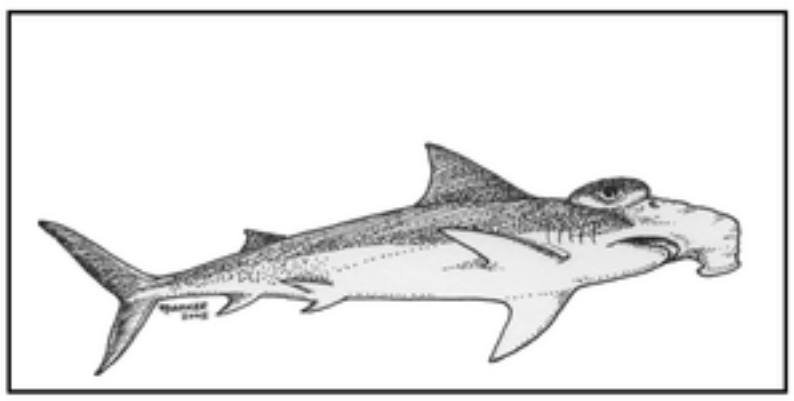
2 Gorilla *ogo* (*Gracilaria salicornia*) has been seen growing in large mats and clumps in Kāneʻohe Bay. This "gorilla" takes over the reef by crowding out other *limu* and coral species. Warning: Suspect aggressive. Apprehend with caution.



3 Crown-of-thorns *(Acanthaster planci)* has been sited in exceptionally large numbers in certain areas of the Pacific. This thorny predator is known to prey on coral. Distinguishing features: barbed-like body that it uses in defense.

4 Prickly seaweed *(Acanthophora spicifera)* is very aggressive and it is reported to be the most widespread alien in the Islands.

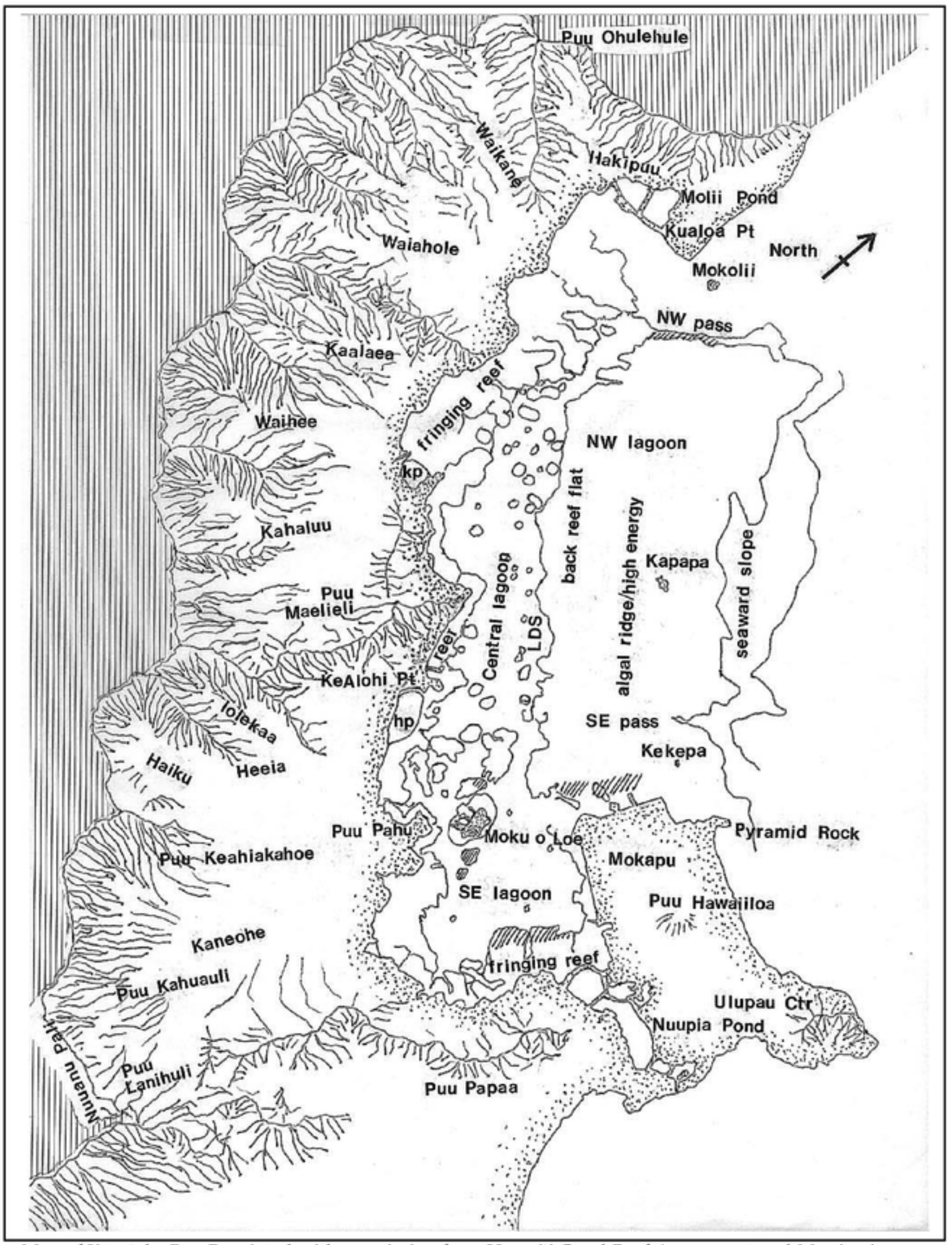
5 Green bubble algae *(Dictyosphaeria cavernosa)* This native species in Kāneʻohe Bay is suspected of using its bubble-like pockets to hide something that might give it an advantage over other species. What might that be?



6 Scalloped hammerhead shark *(Sphyma lewini)* is also known as *manō kihikihi*. Suspect is very efficient predator on the reef and has been spotted in large numbers in Kāneʻohe Bay. It is partial to manta rays. It uses its hammerhead to hold down its victim while biting large chunks from the ray's wings.

CRIME SCENE REPORT

MAP OF KĀNEʻOHE BAY



Map of Kāneʻohe Bay Reprinted with permission from Hawaiʻi Coral Reef Assessment and Monitoring Program