THE MYSTERY OF THE MOSTLY MISSING REEFS — DATA SEARCH NOTES

In this investigation, we will search for a number of clues to help us solve "The Mystery of the Mostly Missing Reefs." The background information below will help you focus your efforts and clarify your tasks at each of the sampling sites at Mokuola.

- **Quadrat Sample**—In this portion of clue retrieval, you will use quadrats to observe the biotic and abiotic elements of Site #2 at Mokuola. You will identify *limu* species and abiotic characteristics of this sample site using the point-intercept model practiced in class. Data will be entered on Evidence Sheet #1 and used to solve your case.

- **Turbidity Trial**—At Site #1 and Site #3 you will conduct a trial, using a turbidity tube, to measure the clarity of water. NTU (Nephelometric Turbidity Units) is the measure of the amount of light scattered by suspended particles (and plankton) in the water. This will help you measure how clear the water is, which has an impact on coral reef development. Please see the Turbidity Conversion Chart on other side of this sheet. Data will be recorded on Evidence Sheet #2.

- **Water Quality Tests (part I)**—At Site #1 and Site #3, you will use water test kits to measure dissolved oxygen, phosphates, and nitrates from surface water samples. Coral reefs, and all other animals in the oceans, are dependent on a sufficient amount of available oxygen in the water. Phosphates and nitrates are released into the water when dead plants and animals decompose. Phosphates and nitrates are also added to water from sewage and animal wastes, soaps, detergents, and lawn fertilizers. If phosphates and nitrates in the water are too high, *limu* and phytoplankton grow rapidly. Phosphates limit precipitation of $CaCO_3$ (calcium carbonate) from seawater, which corals need to build skeletons. Data will be entered on Evidence Sheet #2.

- **Water Quality Tests (part II)**—At Site #1 and Site #3 you will test for salinity and measure the temperature of **TWO** different water samples. Collect surface water samples and immediately measure the temperature using a thermometer, and use the hydrometer to determine salinity. Enter data on Evidence Sheet #2. Gather a second sample of water (at approximately an arm's length depth) and collect the same data. Again, enter these clues on Evidence Sheet #2.

- **Plankton Sampling**—A plankton net will be deployed at Bridge Site for the duration of the other investigations. The net is to be retrieved prior to leaving Mokuola, and a sample collected. Sample will be observed on site and at Mokupāpapa. Density (amount) and diversity of plankton helps signify the health of an ecosystem and high concentrations of phytoplankton can contribute to turbidity.

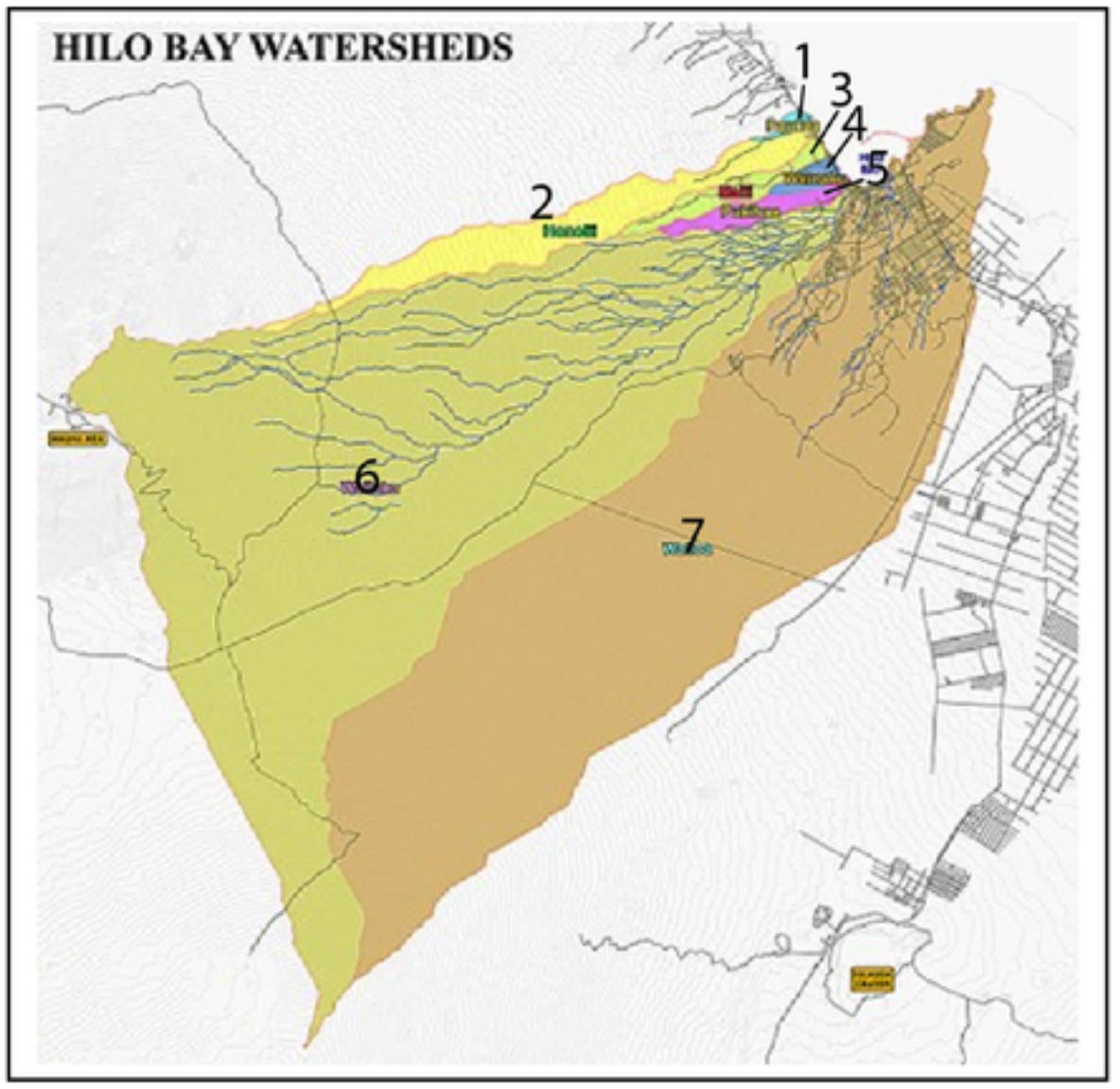
THE MYSTERY OF THE MOSTLY MISSING REEFS

DATA SEARCH NOTES

TURBIDITY CONVERSION CHART

Centimeters	Approximate NTUs (Transparency values)
6.4 – 7.0	240
7.1 – 8.2	185
8.3 – 9.5	150
9.6 – 10.8	120
10.9 – 12.0	100
12.1 – 14.0	90
14.1 – 16.5	65
16.6 – 19.1	50
19.2 – 21.6	40
21.7 – 24.1	35
24.2 – 26.7	30
26.8 – 29.2	27
29.3 – 31.8	24
31.9 – 34.3	21
34.4 – 36.8	19
36.9 – 39.4	17
39.5 – 41.9	15
42.0 – 44.5	14
44.6 – 47.0	13
47.1 – 49.5	12
49.6 – 52.1	11
52.2 – 54.6	10
>54.7	<10

(*Chart adapted from: University of Wisconsin Extension. 2006. Water Action Volunteers – Volunteer Stream Monitoring Factsheet Series.*)



(Hilo Bay Watersheds: 1 Paukaʻa, 2 Honoliʻi, 3 Māʻili, 4, Wainaku, 5 Pūkīhae, 6 Wailuku, 7 Wailoa.
Source: Adapted from Hilo Bay Watershed Advisory Group Web site)

Some Key Facts:

- Corals thrive in water temperatures 23-29 ºC.
- Most corals survive in salinities from 32-35 ppt. and can tolerate up to 42 ppt.
- Intermediate NTU range from 15-50, coral require small numbers!
- Minimal DO levels for recreational waters in Hawaiʻi are 60% saturation.
- The natural mean level of phosphates is 0.10 mg/L.
- Nitrate levels above .2 ppm exceed HDOH standards for embayments.

THE MYSTERY OF THE MOSTLY MISSING REEFS — EVIDENCE DATA SHEET 1

Sample Site #2

TEAM NAME: _____ **DATE:** _____

WEATHER CONDITIONS: _____

TIDES: _____ **(SEE: HTTP://WWW.PRH.NOAA.GOV/)**

- With the help of the instructor, fill in the top box in each column.
- Place the quadrats in three different spots at Site #2 (see Mokuola Map).
- 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 sketch at the bottom of this sheet and give the species a name.
- Using the point-intercept method, record each species that touches a point where the lines in the quadrat intersect.

Quadrat Area	Sand	Coral 1	Other Substrate	*Limu* 1	*Limu* 2	Other
1						
2						
3						

In the space to the right, write as many detailed observations of the surrounding environment as possible. Use the list below to help you notice these other factors:

- waves (at sample site, in bay, outside breakwall)
- ship, boat traffic
- currents
- marine debris
- recreational users (fishers, beach-goers, paddlers, tourists, etc.)
- others???

Other Keen Observations

THE MYSTERY OF THE MOSTLY MISSING REEFS EVIDENCE DATA SHEET 2

TEAM NAME: _____ **DATE:** _____

To solve this mystery, all investigators must strive to gather data (clues) as accurately as possible. Make as many keen observations as possible at each site. Good luck, detectives!

Turbidity Trial

Procedure – Conduct two tests for each site.

1. Collect water sample in bucket.
2. Stir the water for 15 seconds. Slowly pour water into turbidity tube, checking frequently to see if you can still see the black and white markings at bottom.
3. When the markings JUST disappear, stop pouring water.
4. Record the height of water in tube (in cm.) Record the NTU value from the chart.

	Mokuola - Site 1		Mokuola - Site 3		Richardson's		Other	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Water Height (cm) in Tube								
NTU* (from chart)								
Visual Description of Water								

* NTU = Nephelometric Turbidity Units

Water Quality Tests - Part I –Phosphate, Nitrate, and Dissolved Oxygen (DO)

Procedure – Conduct two tests at each site.

1. Collect water sample.
2. Follow test kit instructions. Record.

	Mokuola - Site 1		Mokuola - Site 3		Richardson's		Other	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Nitrate Level								
Phosphate Level								
Dissolved Oxygen								

THE MYSTERY OF THE MOSTLY MISSING REEFS EVIDENCE DATA SHEET 2

TEAM NAME: _____ **DATE:** _____

Water Quality Tests - Part II – Temperature and Salinity

Procedure Conduct two tests at each site.

1. Collect surface water sample.
2. Using thermometer and hydrometer, measure temperature and salinity. Record.
3. Using collection bottle, extend below surface a full arm's length. Open, collect at depth.
4. Using thermometer and hydrometer, measure temperature and salinity. Record.

	Mokuola - Site 1		Mokuola - Site 3		Richardson's		Other	
	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Salinity (Surface)								
Salinity (Depth)								
Temperature (Surface)								
Temperature (Depth)								

Note: Record temperature readings that were obtained from Richardson's and other site when water was collected by the field trip leader.

Plankton Sampling

Follow instructor's procedures.

In the space to the right, write as many detailed observations of the surrounding environment as possible. Use list below to help you notice these other factors:

- waves (at sample site, in bay, outside breakwall)
- ship, boat traffic
- currents
- marine debris
- recreational users (fishers, beach-goers, paddlers, tourists, etc.)
- others???

Other Keen Observations

THE MYSTERY OF THE MOSTLY MISSING REEFS LEARNING LOG - 6

DETECTIVE'S NAME: _____ **DATE:** _____

Your task:

- Find out why the reefs are mostly missing in Hilo Bay!
- Gather evidence of what has happened or is happening to corals.

Hypothesis: Write your hypothesis about who/what is negatively affecting coral reef development in Hilo Bay.

Method: Describe the method you will use to solve the case and test your hypothesis.

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

THE MYSTERY OF THE MOSTLY MISSING REEFS — SITUATION REPORT

PRELIMINARY INVESTIGATOR: Dr. Pheelay O'Pheesh, OD (Ocean Detective)
LOCATION: Mokuola (Coconut Island in Hilo Bay; see map provided)

THE SITUATION: Corals are in short supply in Hilo Bay. Few are found just inside the breakwall and the reefs in the outer bay are not as well developed as coral reefs in other places on our island. We know that the breakwall minimizes wave action. Evidence shows sediments entering the bay from Wailuku and Wailoa rivers. In addition, fresh water from both of these rivers, and from places like Ice Pond in Reed's Bay, empty into the bay. There appears to be minimal organisms at Mokuola, although I did observe some *limu*. We also know that much boat and ship traffic occurs in the bay due to the commercial Harbor and Wailoa Boat Ramp. Most residents believe our bay is polluted and do not really want to swim there! We need more information to explain why the reefs are mostly missing!

INVESTIGATOR'S NOTES: HISTORY OF HILO BAY:

In 1790-1 Maka O Kū Heiau was built at Mokuola. From a spot where the Naniloa Hotel is, lookouts could see any war canoes rounding Leleiwi or Pepeʻekeo points. In the late 18th century, Hilo Bay served as the community gathering place for residents of Hilo. The black sand beach stretched continuously from Wailoa to Wailuku River. This beach was used as the principal landing for both passengers and cargo. Just *mauka* of the beach were numerous *loʻi* and *loko iʻa*. By filling wetlands, diverting Waiolama Stream, developing *mauka* areas, constructing the breakwall, and dredging the harbor and channel, people have drastically altered the ecology and hydrology of Hilo Bay.

KEY EVENTS:

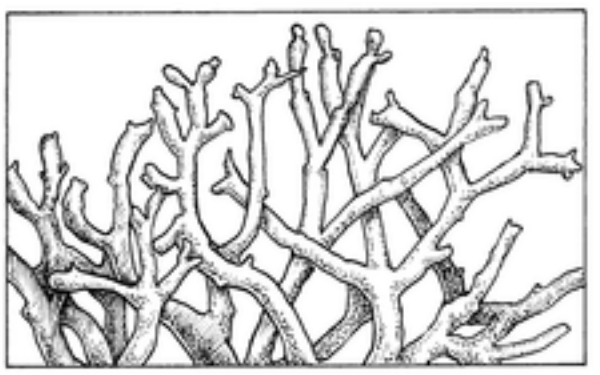
- 1906 – Hilo's first sewer system completed; raw sewage dumped directly into Hilo Bay.
- 1913 – Dredging of Hilo Harbor begins.
- 1917 - Public Works constructs a canal to divert Waiolama Stream into Wailoa River. A major portion of black sand beach disappears.
- 1929 – Hilo breakwall completed.
- 1946 – April 1, tsunami generated in Aleutian Islands devastates Hilo and rips hole in breakwall; repairs made.
- 1952 – A study of territorial government estimates 3.5 million gallons of raw sewage enter the bay daily.
- 1960 – May 23, tsunami devastates Mokuola and much of downtown Hilo.
- 1966 – Sewage outfall moved to Puhi Bay, outside of the breakwall.
- 1998 – Hilo Bay waters formally included on U.S. Environmental Protection Agency's list of impaired water bodies.
- 2005-2008 – Formal studies by U.S. Army Corps of Engineers on circulation patterns and UHH research on water quality conducted.

SUSPECTS:

All of the following are suspects that we must investigate! I, as principal investigator, have decided to separate the primary suspects into two categories: biotic and abiotic.

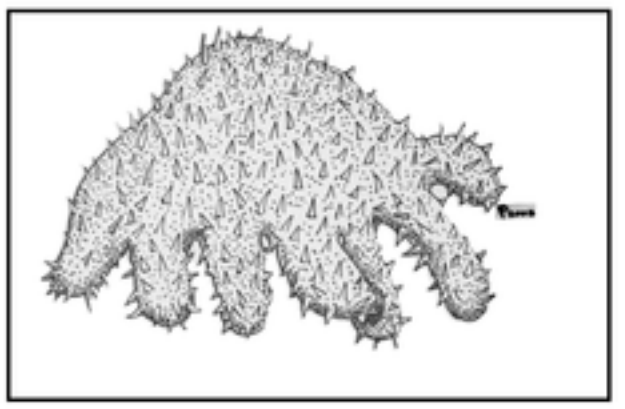
Biotic Suspects

1 Gorilla *ogo* (*Gracilaria salicornia*) has been seen in many places on Hawaiʻi Island. This "gorilla" takes over the reef by crowding out other *limu* and coral species. Warning: Suspect aggressive. Use caution.



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

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.



Abiotic Suspects

4 Sediments—Large amounts of sediments enter the bay, particularly from Wailuku River. These particles physically damage coral polyps and minimize the available light required for photosynthesis.

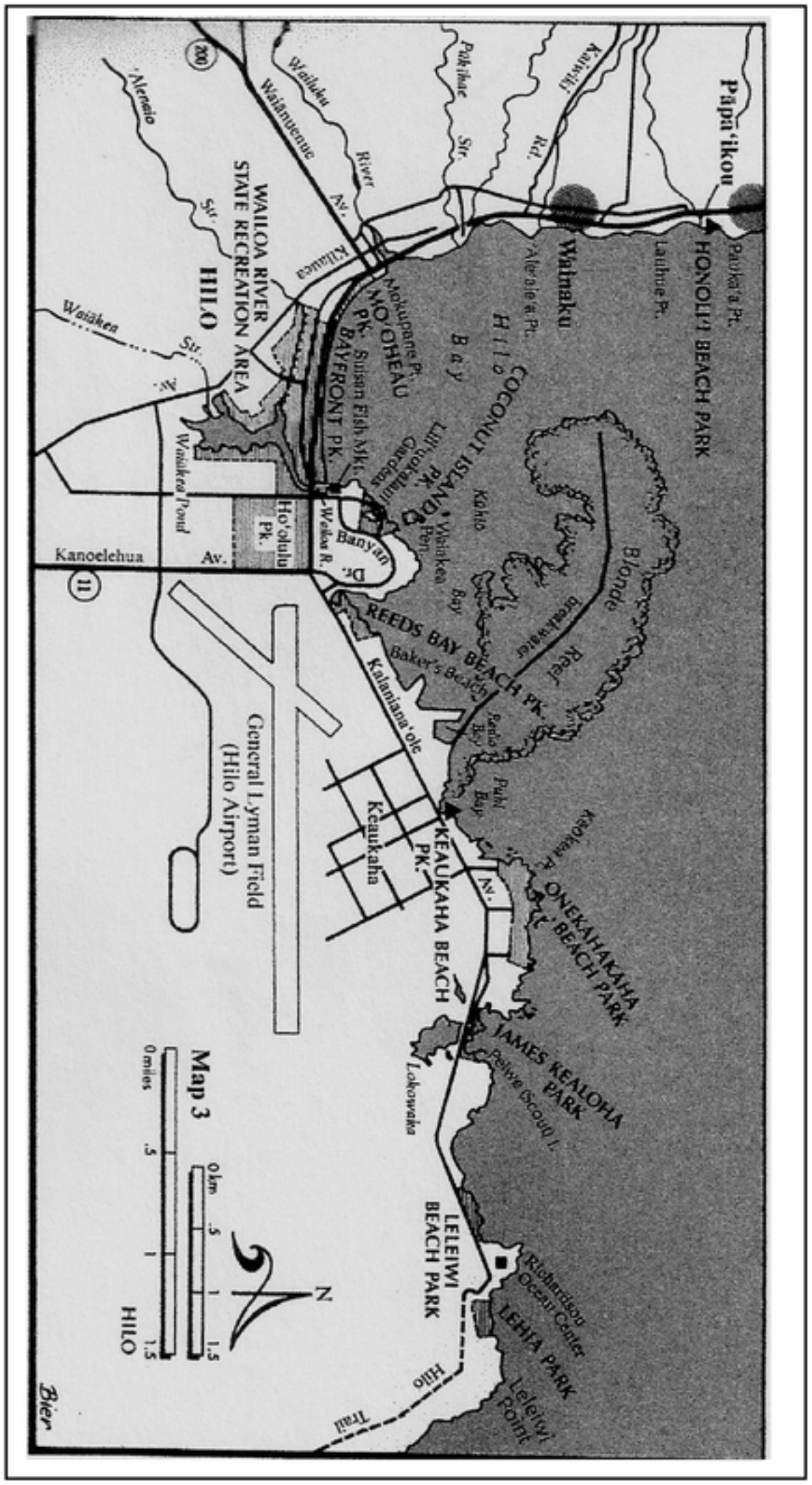
5 Fresh Water—Significant influxes of fresh water have been known to negatively impact coral reef growth and development. Circulation in Hilo Bay is currently being studied, but it is known that fresh water does move offshore.

6 Pollutants—Runoff and groundwater sources contribute excess levels of pollutants like nitrates and phosphates that can stimulate algal blooms, which impact water clarity.

7 The Breakwall—Constructed between 1908 and 1929, this structure provides a refuge for Hilo Harbor. Corals have been seen growing on the breakwall boulders both on the inside and outside. Many believe the breakwall "messes up the bay."

SITUATION REPORT

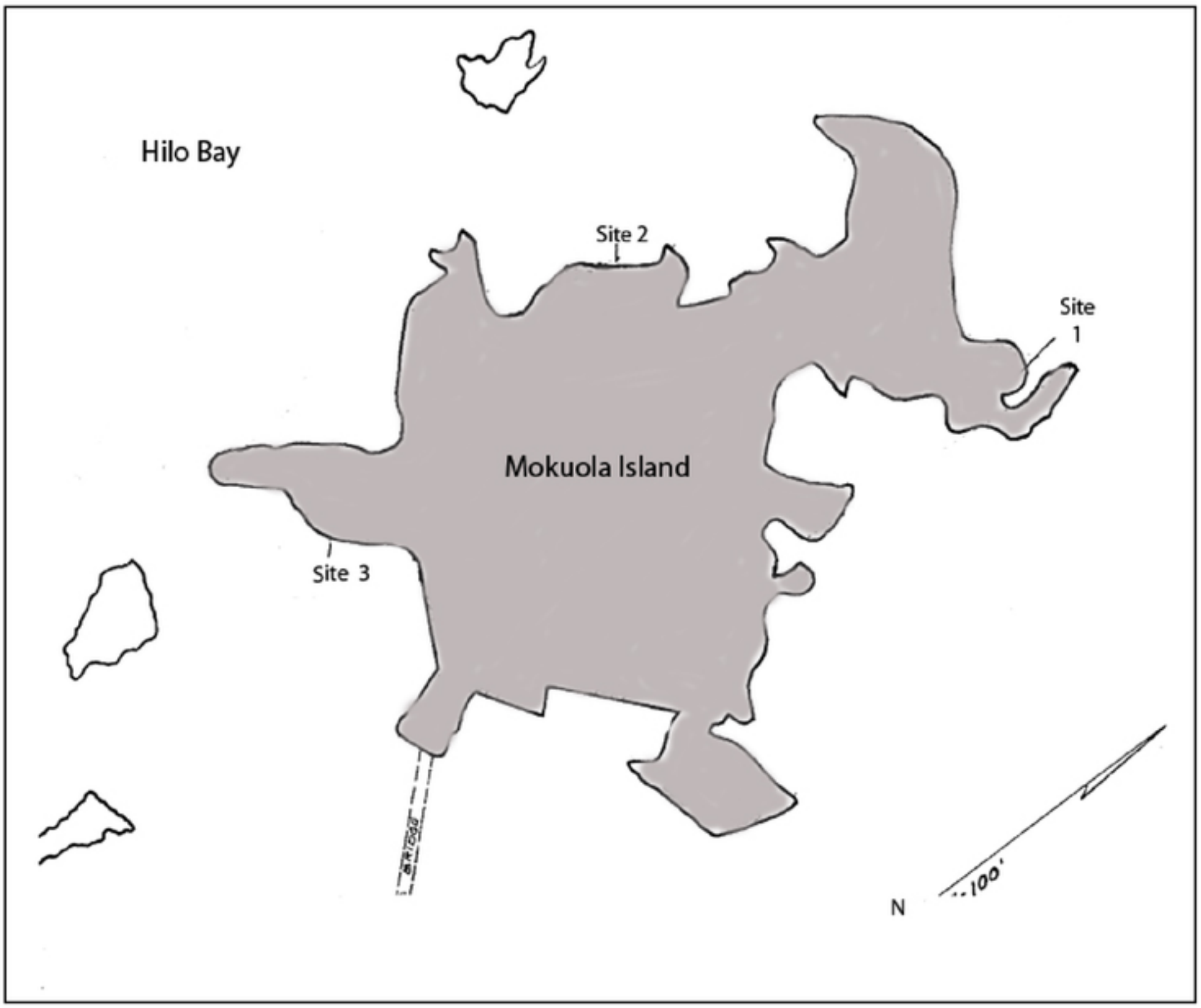
MAP OF HILO BAY WATERFRONT



Map of Hilo Bay Waterfront Reprinted from: Clark, John R.K. 1985. *Beaches of the Big Island*. University of Hawaii Press. Honolulu, HI.

SITUATION REPORT

MAP OF MOKUOLA (COCONUT ISLAND)



Map of Mokuola Island adapted from County of Hawai'i Tax Map Key, County of Hawai'i Planning Department

STUDENT READING

The Legend of Mānaiakalani and Mokuola

In Hilo Bay, on the island of Hawaiʻi, there is a cay (or small island) known as Mokuola, or "island of life." Mokuola was considered a *puʻuhonua*. As with all *puʻuhonua*, Mokuola is *wahi pana* (sacred place). Here, defeated warriors and other *poʻe* could seek peace, safety, and refuge. This legend describes how Mokuola came to be.

Māui, the Hawaiian demigod, possessed Kamakaunuiamaui, a great, magic fishhook. Because this *makau* was so special and powerful, Māui would never show it to anyone, including his family. Māui also had a magic *waʻa* that could carry him from *moku* to *moku* with only two strokes of his *hoe*.

One day, as he was watching a *waʻa* leave for a neighbor island, Māui felt sorry for his people; for they did not hold the magic that he had. So, he decided that the islands should be joined together to make it much easier for the *poʻe* to travel from *moku* to *moku*.

He called together the *aliʻi* and other people and told them that he would need their help in order to achieve this wondrous feat. In the meeting, he warned all that would come to *kōkua* that they must never look back until all of the islands were connected and *paʻa*.

On the appointed day, Māui fastened the magic *makau* into the island of Māui and the *kāne* paddled and pulled as hard as they possibly could!

The islands began to move, getting closer and closer with the men's strong strokes. Just as the island of Māui was about to connect to Hawaiʻi Island, an *aliʻi* (whom many believe to be Māuiʻs own brother) glanced back from where the island had been pulled.

This action shattered the spell Māui had cast with Kamakaunuiamaui! All of the islands slid back into their original positions, except the small piece attached directly to Māui's magic hook.

This piece landed in Hilo Bay and is now known as Mokuola. To this day, some people of Hāna, Māui, claim the island belongs to the island of Māui! If you travel to this *wahi pana*, you can even see the spot where Kamakaunuiamaui was attached. To see the magic hook itself, look to the sky in the starline of Mānaiakalani on a summer night.

VOCABULARY

puʻuhonua.— place of refuge, asylum, place of peace and safety
wahi pana — sacred place, celebrated place
poʻe — people
makau — fishhook
ʻohana kuleana— caretakers, people responsible
waʻa — canoe; pahi is the old word from Kalani's land of origin
moku — island
aliʻi — chief
kōkua — to help
paʻa — firm, solid, fixed, secure
kāne — male, men

KEY EVENTS AND FACTS REGARDING MOKUOLA

- 1790-1 Maka O Kū Heiau is built at the same time as Puʻukoholā. From a spot where the Naniloa Hotel is, lookouts could see any war canoes rounding Auwili or Pepeʻekeo points.
- 1897 - Isaac Kekihiokala Keliʻipio is appointed *ʻohana kuleana* of Mokuola by the territorial legislature. Keliʻipio *ʻohana* resides on Mokuola until 1930.
- 1920 - Military uses Mokuola as a recreational site; building a jumping tower and a slide on sacred Mokuola rock, the namesake of the island.
- 1930 - Isaac Kekihiokala Keliʻipio passes; wife Mary becomes caretaker.
- 1932 - Grandmother Mary's house is erected on the mainland near the edge of the present Hilo Hawaiian Hotel. Family lives there until 1946 tsunami.
- 1947 - Mary Keliʻipio retires. Paul Keliʻipio, her son assumes caretaker duties.
- May 23, 1960 - A tsunami generated off South America devastates Mokuola, Waiakea, and much of Hilo town. County decides NOT to rebuild caretaker's cottage; Keliʻipio family relocates to Keaukaha.

READING RESPONSE

1. Why was Mokuola a *wahi pana*?

2. Why do some people from the island of Maui believe that Mokuola belongs to their island?

3. How have human uses of Mokuola changed from 1790 to the present?

REFERENCES

ʻImi Naʻauao ʻOhana Waʻa Crew Training. 2009. Adapted from poster Nā ʻOhana Hōkō ʻEha, The Four Star Families. ʻImiloa Astronomy Center of Hawaiʻi. Hilo, HI.

Keliʻipio-Young, Lilinoe. April 1, 2009. Personal Communication.