Marine Unit 2

Marine Relationships

Overview

This unit revolves around the theme of relationships in the Hawaiian marine environment. This unifying theme gives students a context in which to learn about many marine species and their role in the marine environment.

First, students explore the relationships between animals and their marine environment by learning about characteristics and adaptations of many Hawaiian marine fish species. Then, students examine trophic levels and how food webs in Hawaiian waters can represent one type of relationship among marine plants and animals. Finally, students explore relationships between people and marine plants and animals important in traditional Hawaiian culture and in the other cultures that shape today's Hawaiian society.

Length of Entire Unit

Four class periods plus research time for student projects

Unit Focus Questions

1) How are Hawaiian marine animals adapted to their environment?

2) How do food web relationships help to explain ciguatera fish poisoning among humans?

3) What is the cultural significance of Hawaiian marine life?

Unit at a Glance

Activity #1
Adaptation Concentration

Students watch a video and play a game to learn about native Hawaiian marine animals and how they are adapted to the marine environment.

Length
One class period followed by homework reading and questions

Prerequisite Activity
None

Objectives
- Identify native Hawaiian marine animals and characteristics that help them survive in particular habitats.
- Identify, explain, and give examples of characteristics exhibited by Hawaiian marine animals that suit them to particular marine environments and ecological roles.

DOE Grades 9-12 Science Standards and Benchmarks
DOING SCIENTIFIC INQUIRY: Students demonstrate the skills necessary to engage in scientific inquiry.
- Formulate scientific explanations and conclusions and models using logic and evidence.

Activity #2
Marine Food Webs

Students create food webs using native Hawaiian marine organisms and examine the effect of bioaccumulation on the flow of toxic organisms through these webs.

Length
Two class periods

Prerequisite Activity
None

Objectives
- Illustrate trophic levels using examples of Hawaiian marine species.
- Illustrate the concept of bioaccumulation using ciguatera fish poisoning as an example.

DOE Grades 9-12 Science Standards and Benchmarks
USING UNIFYING CONCEPTS AND THEMES: Students use concepts and themes such as system, change, scale, and model to help them understand and explain the natural world.
- MODEL: Design or create a model to represent a device, a plan, an equation, or a mental image.

Activity #3
Marine Life Scrapbooks

Students assemble scrapbooks about the natural history and cultural significance of native Hawaiian marine species.

Length
One class period plus research time

Prerequisite Activity
None
This activity could be a culminating activity for the first two activities in this unit.

Objectives
- Summarize prior learning about native Hawaiian marine species.
- Research, represent, and describe the cultural significance of one or more Hawaiian marine species.
- Conduct library research and personal interviews to gather historical and cultural information.

DOE Grades 9-12 Science Standards and Benchmarks
LIVING THE VALUES, ATTITUDES, AND COMMITMENTS OF THE INQUIRING MIND: Students apply the values, attitudes, and commitments characteristic of an inquiring mind.
- SELF-DIRECTED: Use research techniques and a variety of resources to complete a report on a project of one’s choice.

Enrichment Ideas

- Make fish prints or rubbings using several different types of fish purchased from a local fish market.

- Find images and descriptions of marine habitats in *An Underwater Guide to Hawai‘i* (Ann Fielding and Ed Robinson, University of Hawai‘i Press, Honolulu, 1987). Pages 21-23 describe a variety of underwater habitats, and there are many photos that show aspects of habitats. Design a marine organism to fit a depicted habitat.

- Do the “Designer Fish” activity from the Aquatic Project WILD curriculum guide (available by attending an Aquatic Project WILD workshop offered by the Hawai‘i Department of Land and Natural Resources Division of Aquatic Resources).

- Form a circle with each student holding one of the Food Chains and Webs cards from Activity #2. Tie the end of a ball of string to someone’s waist and have that person toss the ball to another student holding an organism card to which they are linked in a food web. Continue until all students are part of the web. Have the entire circle lean back and feel the strength of the web supporting the whole group. Then cut one link with a scissors, showing the impact of a small action on the whole web. Discuss what this activity demonstrates to students about food webs.

- Have students research what happens to energy at each step of the food chain and explain why energy would be lost at each level.

- Research occurrences of ciguatera poisoning on Maui and the other Hawaiian Islands. Look for patterns such as where many ciguatoxic fish are caught and which fish species seem to be implicated the most often.

- Culminate the unit with a *hō'ike* or series of class presentations. Each student or group could report on what they learned about the natural history and cultural significance of marine species in Hawai'i (Activity #3 "Marine Life Scrapbooks"). Portions of audio and videotaped sessions could be included, as well as examples of items or food dishes made with marine species. Students researching seaweed or species with shells could bring specimens to class.

- Teach younger students about native Hawaiian marine life by presenting scrapbooks at nearby elementary schools.

Resources for Further Reading and Research

On Ciguatera Poisoning

Epidemiology Branch, *Fish Poisoning in Hawai'i*, State of Hawai'i, Department of Health, Honolulu, 1997.

Hawai'i Department of Health online public health resources, "Ciguatera Fish Poisoning" at <www.hawaii.gov/doh/resource/comm_dis/cddcigua.htm>.

Cigua-Check Fish Poison Test Kit website at <www.cigua.com>.

Shirai, J. L., L. K. Shirai, and Y. Hokama, *Seafood Poisoning: Ciguatera*, Yosh Hokama Family Trust, Gardena, California, 1991.

On Marine Species and Their Cultural Significance

Abbott, Isabella, and E. H. Williamson, *Limu — An Ethnobotanical Study of Some Edible Hawaiian Seaweeds,* Pacific Tropical Botanical Garden, Lawai, Hawai'i, 1974.

Fortner, Heather J., *The Limu Eater* Sea Grant Misc. Report, UNIHI-SEAGRANT-MR-79-01, 1978.

Hobson, Edmund S. and E. H. Chave, *Hawaiian Reef Animals*, University of Hawai'i Press, Honolulu, 1990

Hoover, John P., *Hawaii's Fishes, A Guide for Snorkelers, Divers and Aquarists*, 3rd ed., Mutual Publishing, Honolulu, 1996.

____________, *Hawai'i's Sea Creatures*, Mutual Publishing, Honolulu, 1998.

Kamakau, S. M., *The Works of the People of Old*, Bishop Museum Press, Honolulu, 1976.

Randall, John E., *Shore Fishes of Hawaii*, Natural World Press, Honolulu, 1996.

Taylor, Leighton, *Sharks of Hawai'i, Their Biology and Cultural Significance.* Honolulu: University of Hawai'i Press, 1993.

Titcomb, Margaret, *Native Use of Fish in Hawaii*, University of Hawai'i Press, Honolulu, 1992.

______________, "Native Use of Marine Invertebrates in Old Hawai'i," *Pacific Science*, Vol. 32, No. 4., 1979, pp. 325-386.

Wyban, Carol Araki, *Tide and Current: Fishponds of Hawai'i,* University of Hawai'i Press, Honolulu, 1992.

Activity #1

Adaptation Concentration

● ● ● Class Period One *Adaptation Concentration Game*

Materials & Setup

- *Far from the Cradle* video by Waikiki Aquarium (included with this curriculum)
- VCR

For each group of four to six students

- One set of 20 “Adaptation Concentration” cards (laminated cards included with this curriculum, master, pp. 8-13)
- One “Adaptation Concentration Instructions and Scoring Sheet” (master, pp. 14-15)

For each student

- Student Page “What Good Is It?” (pp. 16-17)

Instructions

1) Show the video, *Far from the Cradle* (20 minutes). Tell students to pay careful attention because they will be playing a game about how marine animals are adapted to their environment using the information from the video.

2) Divide the class into groups of four to six students. Hand out the Adaptation Concentration game materials and have groups play the game according to the instructions given.

3) Play as many rounds as time permits.

4) Play options:
   - Instead of having students fill in the scoring grid, incorporate a simpler assessment component by having students track how many cards they collect in each game.

   - Play the game with teams. Have tournaments by pairing winning teams against each other until a champion emerges. You can structure “double-elimination” tournaments, or use any other tournament structure that makes sense, such as a round robin.

   - If students are playing as individuals, try mixing up the groups for subsequent rounds by placing all of the first-round winners in a new group, second-placers in another group, and so on.

5) Assign the Student Page “What Good Is It?” as homework.

Journal Ideas

- Think about a fish or another marine animal you've seen. Using what you've learned in this activity, describe how it seems to be adapted to its environment.
- Some adaptations, such as the leaf scorpionfish's swaying motions, are called "behavioral adaptations." Instead of being a structural feature such as body shape or eye placement, these adaptations are exhibited in what the animal does. Describe some things that you do that, like behavioral adaptations, help you fit into different physical or social environments.

Assessment Tools

- Student Page "What Good Is It?" (teacher version, p. 7)
- Participation and conduct during the game
- Adaptation Concentration Scoring Grids
- Journal entries

Teacher Version

What Good Is It?

Fill in this grid. Use what you learned about how marine organisms are behaviorally and physically adapted to their environment to spark your thinking.

Fill in the advantage you think each characteristic gives to the marine organisms pictured. Explain your reasoning.

> Note: Well-reasoned responses are acceptable, even if they do not match the answers given on this key.

ADAPTATION	ADVANTAGE	EXAMPLE
Upturned mouth & eyes close to mouth	Pick out plankton swimming freely in the water	Hawaiian dascyllus *ʻĀloʻiloʻi*
Many fang-like teeth	Grasp fish and other prey	Viper moray *Pūhi kauila*
Thin, elongate body shape	Makes the fish hard to see	Trumpetfish *Nūnū*
Light coloration all over	Provides camouflage in sand or surf	Hawaiian flagtail *Āholehole*
Light-colored belly	Makes the fish hard to see from from below (especially by prey)	Whitetip reef shark *Manō lālā kea*
Brooding eggs in mouth	Keeps the eggs protected	Cardinalfishes *ʻUpāpalu*

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Larvae in plankton

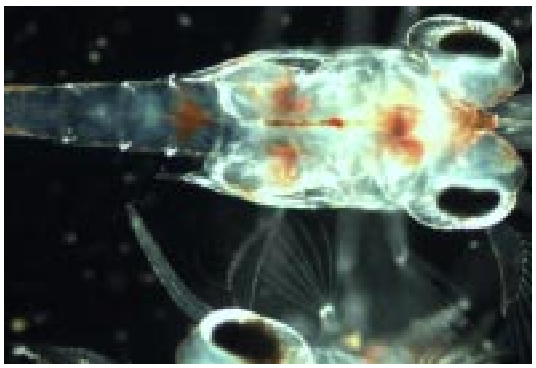
Makes the larvae difficult to see floating in the water, reduces chance of predation

Juvenile convict tang - *Manini*

(Acanthurus triostegus)

Protects from predators, provides abundance of algae and small invertebrates for food

Photo: Karl Embleton, Sir Alister Hardy Foundation for Ocean Science



Transparency

Photo: Waikiki Aquarium

Seeking out sheltered backwater areas or tidepools

Zebra blenny - *Pāo‘o*

(Istiblennius zebra)

Reduces predation by birds and land animals while feeding on algae in tidepools

Zebra blenny - *Pāo‘o*

(Istiblennius zebra)

Reduces predation by birds and land animals by blending in with the dark rock and shadowy holes and crevices in the lava rock of tidepools

Photo: Marjroie L. Awai in John P. Hoover Hawaii's Fishes, Mutual Publishing

Quick, darting movements, constant movement

Photo: Marjroie L. Awai in John P. Hoover Hawaii's Fishes, Mutual Publishing

Dark color

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Parrotfish - *Uhu*
(*Scarus perspicillatus* pictured)

Scrape algae from the surface of coral reef

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Teeth fused into strong, beaklike plates

Moorish idol - *Kihikihi*
(Zanclus cornutus)

Reaches sponges and similar invertebrates living in crevices and holes

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Elongated, tubular mouth

Convict tang - *Manini*
(Acanthurus triostegus)

Makes the fish more difficult to drive off than a single fish feeding on algae

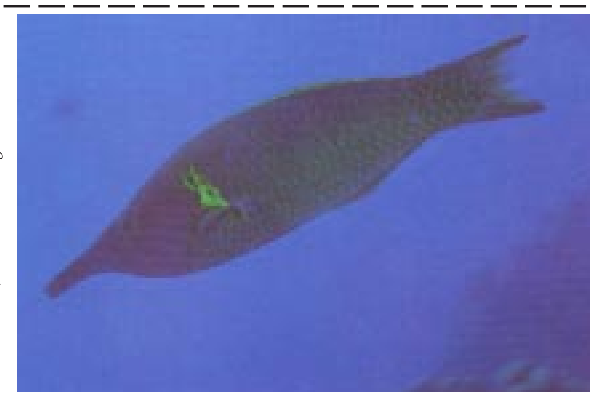
Photo: John P. Hoover, A Pocket Guide to
Hawai'i's Underwater Paradise, *Mutual Publishing*

Schooling

Bird wrasse - *Hīnālea ʻiʻiwi*
(*Gomphosus varius* - terminal phase pictured)

Reaches small crabs and other prey in crevices and holes

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*



Tubular snout

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Forcepsfish (or Common Longnose Butterflyfish)
Lau wiliwili nukunuku oiʻoi
(*Forcipiger flavissimus*)

Reaches small worms and other invertebrates in crevices and holes

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Long, tubular snout

Goatfish - *Weke*
(*Parupeneus porphyreus* pictured)

Help to detect food in sand

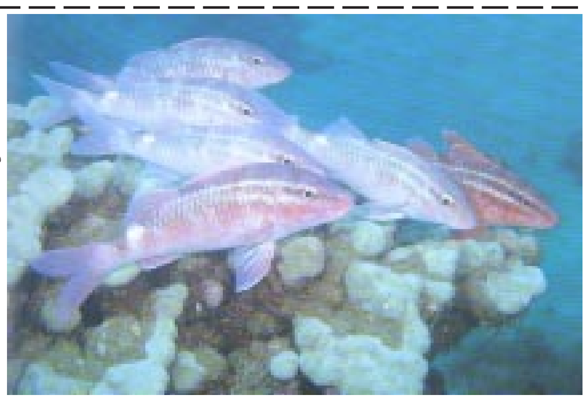
Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Whisker-like barbels

Goatfish - *Weke*
(*Parupeneus porphyreus* pictured)

Helps fish swim close to the bottom, to use barbels better in the sand

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

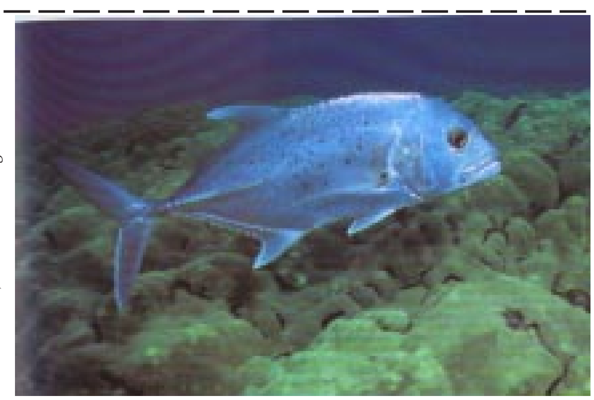


Flat underside

Jack - *Ulua*
(*Caranx ignobilis* pictured)

Helps fish swim swiftly, moving in on small fishes and invertebrates before they can escape

Photo: David R. Schrichte in John P. Hoover,
Hawaii's Fishes, *Mutual Publishing*



Deep, narrow, streamlined body; scythe-like tail

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Dragon Moray - *Pūhi kauila*

Enchelycore pardalis

Helps to maneuver easily in crevices, an advantage in stalking prey; provides quickness, an advantage in striking at prey

Photo: David R. Schrichte in John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Muscular, serpentine body

Devil scorpionfish
Nohu ʻomakaha

Scorpaenopsis diabolus

Conceal the fish from prey, which may swim very close to it

Photo: John P. Hoover Hawaii's Fishes, *Mutual Publishing*

Humped, irregular body shape; coral- and rock-colored camoflauge

Devil scorpionfish
Nohu ʻomakaha

Scorpaenopsis diabolus

Defend against predators

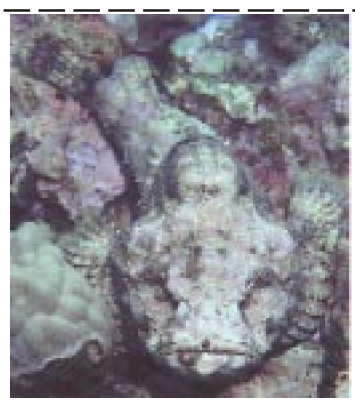


Photo: John P. Hoover Hawaii's Fishes, *Mutual Publishing*

Venomous spines along the back

Leaf scorpionfish
Nohu

Taenianotus triacanthus

Camoflauges and allows the fish to closely approach prey

Photo: Marjorie L. Awai in John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Swaying from side to side like a piece of seaweed in the current

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Leaf scorpionfish
Nohu
(Taenianotus triacanthus)

Allows the fish to strike quickly at prey

Spotted trunkfish or boxfish
Moa
(*Ostracion meleagris* - male pictured)

Defends against predators

Photo: Marjorie L. Awai in John P. Hoover,
Hawaii's Fishes, *Mutual Publishing*

Streamlined body

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Body armored with rigid scales

Spotted trunkfish or boxfish
Moa
(*Ostracion meleagris* - male pictured)

Defends against predators

Hawaiian sergeant
Mamo
(Abudefduf abdominalis)

Allows male to protect eggs against predators

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Secreting toxin through skin

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Attaching eggs to rocks

Adaptation Concentration Cards

Cut on solid lines, fold on dashes

Spotted coral blenny (or shortbodied blenny)
Pāoʻo kauila
(Exallias brevis)

Allows male to protect eggs against predators

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Attaching eggs to rocks

Butterfly fish (Butterfly fish are variously called *lau hau, lau wiliwili,* and *kīkākapu*)
(Chaetodon lunula)

Helps fish sprint quickly for refuge from predators with additional thrust, like foot fins on humans

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Placement of dorsal and anal fins back on the body

Wrasses - *Hīnālea*
(Coris gaimard - initial phase pictured)

Helps the fish disperse eggs in high numbers, instead of concentrating them where predators can easily find them

Photo: John P. Hoover
Hawaii's Fishes, *Mutual Publishing*

Broadcasting eggs and sperm into the water

Adaptation Concentration

Game Instructions

Object
To collect cards from the table by correctly identifying:
- The common or Hawaiian species name AND
- The "advantage" conferred by the adaptation listed on the front of the card.

How to Play
Groups of four to six

1) Deal the cards, photo side up, in a grid on the table. All of the cards should be fully visible.

2) Play begins with the player to the left of the dealer and continues clockwise around the table.

3) Point to a card on the table and state the species name (either common or Hawaiian) and the advantage conferred to the species by the characteristic on the front of the card. Then turn over the card in its spot on the table so everyone can see it. If you correctly stated both the species name and the advantage, take the card and begin a collection pile on the table.

   Continue in this way until you have an incorrect answer. Turn the incorrectly identified card back over, and continue play with the next player to your left.

4) The next player cannot begin his or her turn by pointing to the card that was just incorrectly identified. He or she must correctly identify at least one card before being allowed to select that card.

5) Play ends when all cards have been collected from the table OR when the play goes all the way around the table twice without any player collecting a card. If the latter happens, take turns turning over one card at a time and reviewing the species names and adaptive advantages so the whole group can hear them.

6) At the end of the game, fill out the Adaptation Concentration Scoring Grid by writing your name in the box that corresponds to each card you collected.

7) The player with the most cards wins!

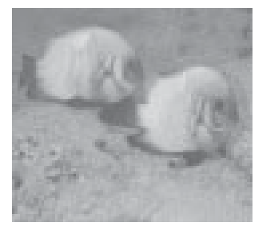
Adaptation Concentration Scoring Grid

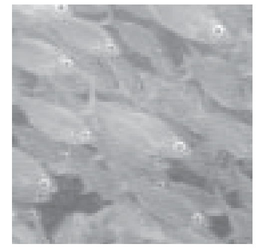
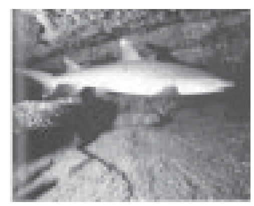
Adaptation	Round 1	Round 2	Round 3
Transparency			
Seeking out sheltered backwater areas or tidepools			
Quick, darting movements; constant movement			
Dark color			
Teeth fused into strong, beaklike plates			
Schooling			
Elongated, tubular mouth			
Tubular snout			
Long, tubular snout			
Whisker-like barbels			
Flat underside			
Deep, narrow, streamlined body; scythe-like tail			
Muscular, serpentine body			
Venomous spines along the back			
Humped, irregular body shape; coral- and rock-colored camoflauge			
Swaying from side to side like a piece of seaweed			
Streamlined body			
Body armored with rigid scales			
Secreting toxin through skin			
Attaching eggs to rocks			
Attaching eggs to rocks			
Broadcasting eggs and sperm into the water			
Placement of dorsal and anal fins back on the body			

What Good Is It?

Fill in this grid. Use what you learned about how marine organisms are behaviorally and physically adapted to their environment to spark your thinking.

Fill in the advantage you think each characteristic gives to the marine organisms pictured. Explain your reasoning.

ADAPTATION	ADVANTAGE	EXAMPLE
Upturned mouth & eyes close to mouth		Hawaiian dascyllus *‘Ālo‘ilo‘i*  *Photo: John Hoover*
Many fang-like teeth		Viper moray *Pūhi kauila*  *Photo: John Hoover*
Thin, elongate body shape		Trumpetfish *Nūnū*  *Photo: John Hoover*

ADAPTATION	ADVANTAGE	EXAMPLE
Light coloration all over		Hawaiian flagtail *Āholehole*  *Photo: John Hoover*
Light-colored belly		Whitetip reef shark *Manō lālā kea*  *Photo: David R. Schrichte*
Brooding eggs in mouth		Cardinalfishes *‘Upāpalu*  *Photo: John Hoover*

Activity #2

Marine Food Webs

● ● ● Class Period One *Constructing Marine Food Webs*

Materials & Setup

For each group of four to six students

- Marine Food Chains and Webs Cards (master, pp. 23-28)
- Student Page “Living and Eating On the Web” (pp. 29-30)
- Three large pieces of paper (at least the size of a flip chart page)
- Colored marking pens, at least three colors per group
- Scotch tape

For each student

- Student Page “Poison Pathways” (pp. 31-33)
- Student Page “Poison Pathways: Questions on the Reading” (pp. 34-35)

Instructions

1) Divide students into groups of four to six.

2) Give each group a set of cards, paper, and marking pens.

3) Have students follow the instructions on the Student Page “Living and Eating on the Web” to create one or more marine food chains (15 minutes).

4) Have each group present its food chain to the whole class, allowing each group two minutes to present.

5) Have students follow the instructions on the student activity sheet to create a marine food web, using all of the cards in the set. NOTE: Groups may want to tape the two remaining sheets of paper together for their food web, since it will be larger than the food chain (20 minutes).

6) Have each group present its food web to the class, allowing each group two minutes to present. If there is time at the end of the class, discuss questions and observations from the activity.

7) Keep the food webs intact for the next class period.

8) As homework, assign the Student Page “Poison Pathways.”

● ● ● **Class Period Two** *Poison Pathways*

Materials & Setup

For each group of four to six students
- Food webs from the previous class period
- One colored marker (of a different color than they used to create their food webs, if possible)

Instructions

1) Divide the class into the same groups as in the previous class. Have each group add to its food web to show how ciguatoxin is transferred between organisms and bioaccumulates in the food chain until it reaches humans. Groups should show how people could get ciguatera poisoning from eating herbivorous fishes as well as from carnivorous fishes. They will need to use information from the Marine Food Chains and Webs Cards as well as the Student Page "Poison Pathways" and will need to draw additional species onto their food webs to illustrate the transfer of ciguatoxin.

2) When groups have finished their work, have each present its results to the class.

3) Discuss student responses to and questions about the homework assignment.

4) As a wrap-up to the "Poison Pathways" activity, share with students the following information from J. L. Shirai, L. K. Shirai, and Y. Hokama, *Seafood Poisoning: Ciguatera*, Yosh Hokama Family Trust, Gardena, California, 1991. This passage provides some insight into the third homework question, which asked students to hypothesize about how *ʻūʻū* or soldierfish might be implicated in cases of ciguatera poisoning:

> Examination of the clinical symptoms in patients with pufferfish, shellfish (red tide due to dinoflagellates) and polyether type toxin (ciguatoxin, okadaic acid, brevetoxin and other polyether) poisonings shows that the symptoms overlap and the causative toxins can't be distinguished. In other words, there is no unique feature that separates the clinical effect. The temperature reversal was supposedly unique for ciguatoxin. This is no longer the case as…okadaic adid, palytoxin, brevetoxin and other ciguatoxin-like compounds including organophosphates and botulism toxin can produce this clinical effect (p. 9).

Journal Ideas

- Draw a food web that includes some of your favorite foods and illustrates their relationship with other organisms when they (or their constituent ingredients) were alive.
- If you got ciguatera poisoning or another kind of seafood poisoning, would you change anything about your fishing or eating habits? If so, what? If not, why not?

Assessment Tools

- Group food chains and webs and in-class presentations (Evaluate based on reasoning, consistency with information given on the cards, and clarity of presentation.)
- Student Page "Poison Pathways: Questions on the Reading" (teacher version, pp. 21-22)
- Group ciguatoxin bioaccumulation illustrations and in-class presentations
- Journal entries

Teacher Version

Poison Pathways: Questions from the Reading

1) Draw a food chain showing how a person could get ciguatera poisoning from eating one of the herbivorous fishes.

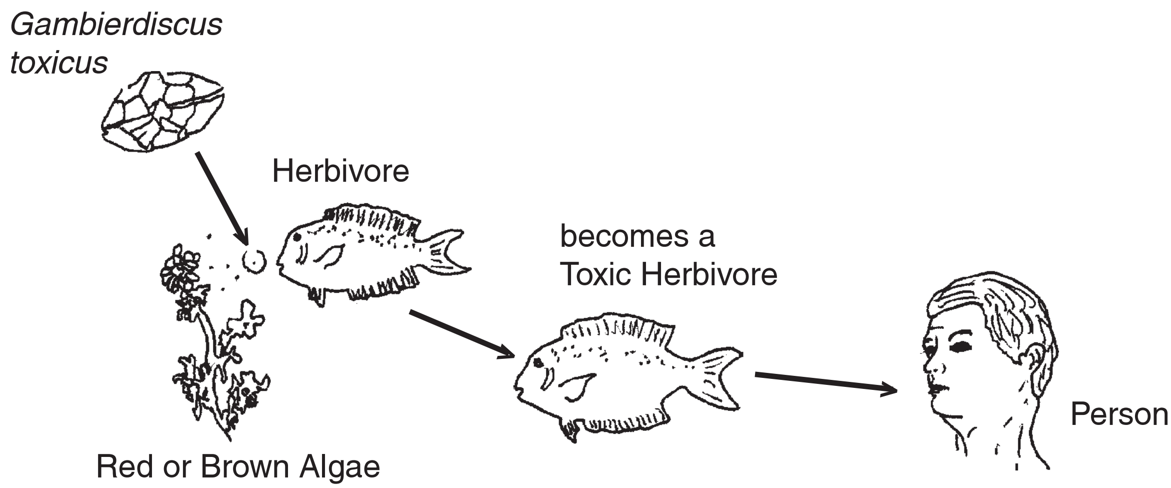


Image after J. L. Shirai, L. K. Shirai, and Y. Hokama, Seafood Poisoning: Ciguatera, *Yosh Hokama Family Trust, Gardena, California, 1991*

2) Draw a food chain showing how a person could get ciguatera poisoning from eating one of the carnivorous fishes.

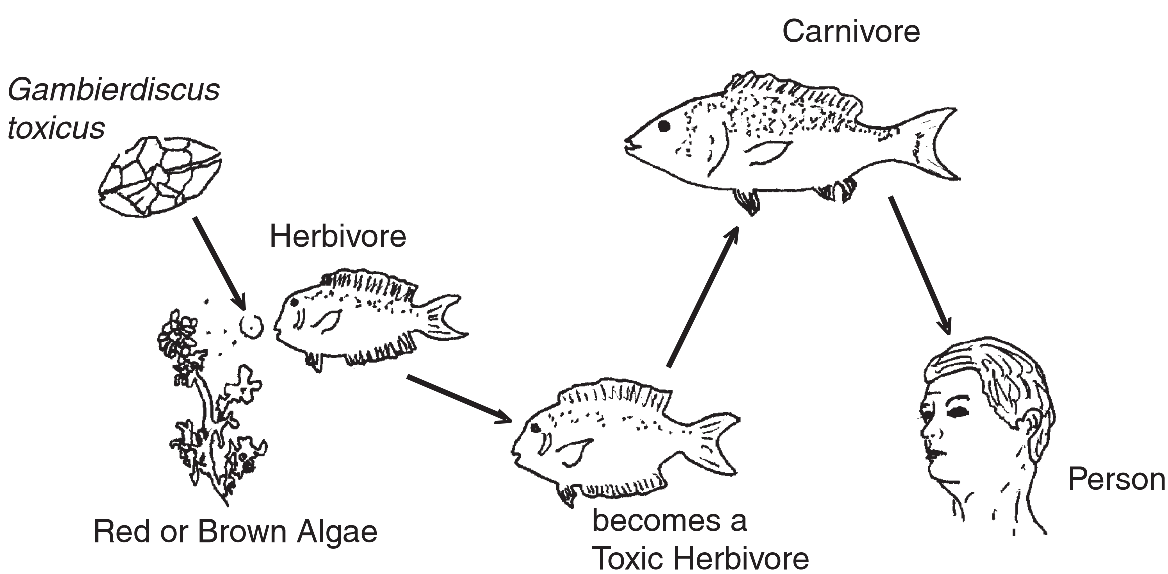


Image after J. L. Shirai, L. K. Shirai, and Y. Hokama, Seafood Poisoning: Ciguatera, *Yosh Hokama Family Trust, Gardena, California, 1991*

3) *ʻŪʻū* or soldierfish do not fit into the two categories of fish that become ciguatoxic: herbivores that graze on "toxic" algae, and carnivores that feed on toxic herbivores. *ʻŪʻū* feed on plankton in midwater—away from the algae growth. Come up with one possible explanation for the fact that *ʻūʻū* have been implicated in at least one case of ciguatera poisoning in Hawaiʻi and describe it below in as much detail as you can. (You do not need to do additional research to formulate your explanation, but make sure you clearly explain your idea and your reasoning.)

Possible answers include:

- It was a case of mistaken reporting by the person who got ciguatera.
- As *ʻūʻū* feed on plankton, they may ingest *Gambierdiscus toxicus* dinoflagellates that dislodged from the algae, perhaps by wave action, and are floating freely in the water.
- There may be other toxins that are chemically similar to the ciguatoxin and cause the same symptoms but come from other sources, for example, within the plankton.
- There may be other types of dinoflagellates that produce ciguatoxin, and these may be found in the plankton that *ʻūʻū* feed on.

Marine Food Chains and Webs Cards

Cut on solid lines

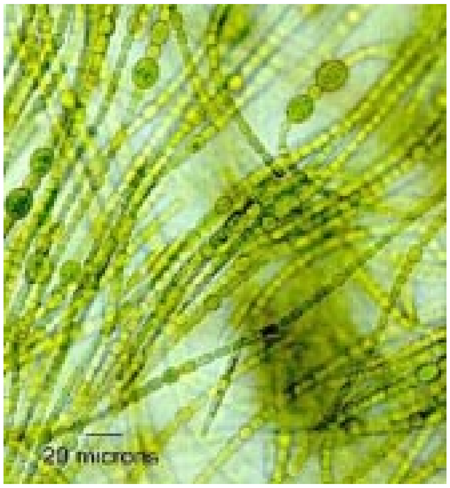


Photo: Roger Burks (University of California, Riverside), Mark Schneegurt (Wichita State University), Cyanosite (www-cyanosite.bio.purdue.edu/index.html)

Blue-green algae (Cyanobacteria)

These are primitive plant-like organisms which receive energy from the sun for photosynthesis. Some live on the surface of *limu* and are eaten along with the algae.

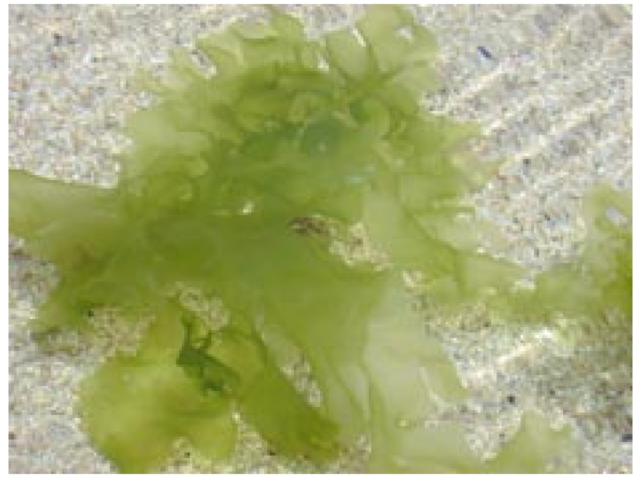
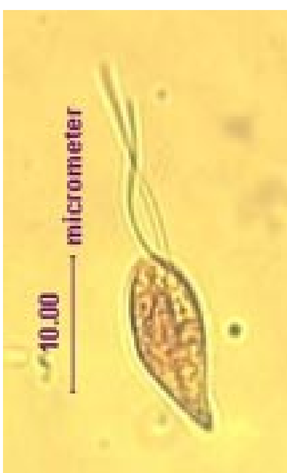


Photo: Kim Martz and Forest Starr

Limu (various species of seaweed)

Grows on rocks
Receives energy from the sun for photosynthesis



Photos: Karl Embleton, Sir Alister Hardy Foundation for Ocean Sciences

Phytoplankton

These are microscopic plants floating in the water which receive energy from the sun.

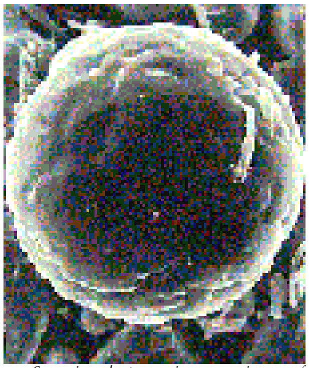
Photo: Karl Embleton, Sir Alister Hardy Foundation for Ocean Sciences

Zooplankton

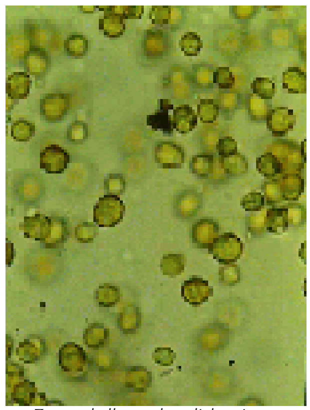
Most are tiny animals floating in the water, but some are larger, like jellyfish. The smallest ones feed on phytoplankton; larger ones eat smaller zooplankton.

Marine Food Chain and Web Cards

Cut on solid lines



Scanning electron microscope image of zooxanthellae (Photos: Scott R. Santos, SUNY at Buffalo)



Zooxanthellae under a light microscope

Zooxanthellae

Single-celled algae cells living in coral tissue that photosynthesize and provide the coral with 90% of its food

Photo: Jan Barosh in John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Spiny porcupinefish - *Kōkala* (*Diodon holocanthus*)

Feeds on snails and crabs

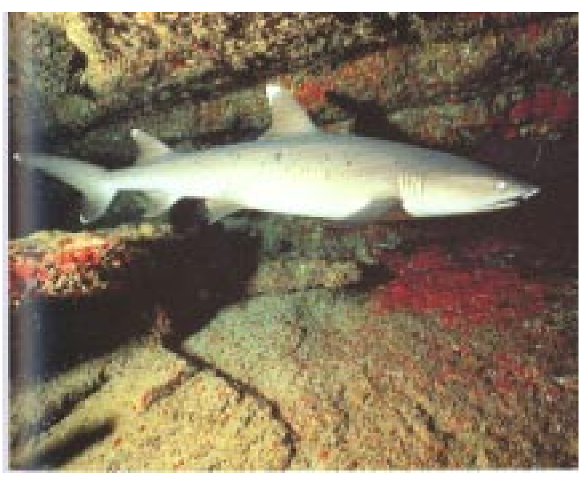


Photo: David R. Schrichte in John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Whitetip reef shark - *Manō lālā kea* (*Triaenodon obesus*)

Feeds at night on reef fish, octopus, lobster and crabs

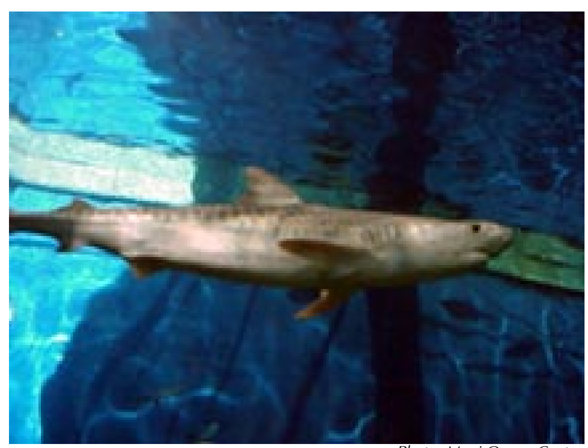


Photo: Maui Ocean Center

Tiger shark - *Niuhi* (*Galeocerdo cuvier*)

Feeds on octopuses, crabs, sharks, rays, porpoises, seabirds, turtles, lobsters, slow-swimming fishes

Marine Food Chain/Web Cards

Cut on solid lines

Photo: *John P. Hoover,* Hawaii's Fishes, *Mutual Publishing*

Bigeye scad - *Akule*
(*Selar crumenophthalmus*)
Feeds on zooplankton

Photo: *John P. Hoover,* Hawaii's Fishes, *Mutual Publishing*

Hawaiian dascyllus - *ʻĀloʻiloʻi*
(*Dascyllus albisella*)
Feeds on zooplankton

Photo: *Scott Johnson in John P. Hoover,* Hawaiʻi's Sea Creatures, *Mutual Publishing*

Penniform cone snail - *Pūpū pōniuniu* (*Conus pennaceus*)
Feeds on other snails

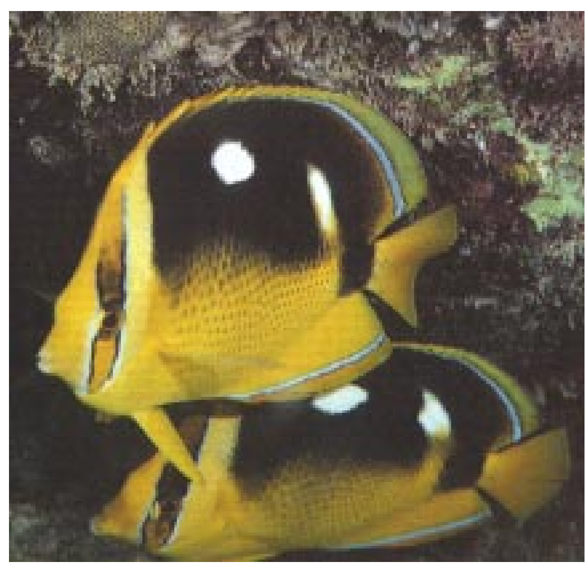


Photo: *John P. Hoover,* Hawaii's Fishes, *Mutual Publishing*

Fourspot butterflyfish - *Lau hau*
(*Chaetodon quadrimaculatus*)
Feeds on coral polyps

Marine Food Chain/Web Cards

Cut on solid lines

Photo: Philip Thomas

Yellowmargin moray eel - *Pūhi paka* (*Gymnothorax flavimarginatus*)
Feeds on reef fish and octopus

Photo: John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

Eyestripe surgeonfish - *Palani* (*Acanthurus dussumieri*)
Feeds on algae

Photo: David R. Schrichte in John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing*

Day octopus - *He'e mauli* (*Octopus cyanea*)
Feeds on crabs and snails

Photo: Kim Martz and Forest Starr

Green sea turtle - *Honu* (*Chelonia mydas*)
Feeds on algae

Marine Food Chain/Web Cards

Cut on solid lines

Photo: John P. Hoover, Hawaii's Fishes, Mutual Publishing

Manta ray - *Hāhālua*
(*Manta* spp.)
Feeds on zooplankton

Photo: Philip Thomas

Cauliflower coral - *ʻĀkoʻakoʻa* or *Puna kea*
(*Pocillopora meandrina*)
Take energy primarily from zooxanthellae (which produce energy directly from the sun) in their tissues and also feed on zooplankton

Photo: John P. Hoover, Hawaii's Fishes, Mutual Publishing

Bluefin trevally - *ʻOmilu*
(*Caranx melampygus*)
Feeds on fishes

Photo: John P. Hoover, Hawaii's Fishes, Mutual Publishing

Spectacled parrotfish - *Uhu uliuli*
(*Scarus perspicillatus*)
Feeds on algae found on the surface of dead coral and on the zooxanthellae in live coral

Marine Food Chain/Web Cards

Cut on solid lines

Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing*

Cowries - *Leho* (*Cypraea spp.*)
(Tiger Cowrey, *Cypraea tigris*, shown)
Most eat algae.

Living and Eating On the Web

As on land, the sun provides the energy for photosynthesis in the ocean. All photosynthesis takes place in relatively shallow water—or in the top layer of the ocean where the water is deeper. Sunlight is filtered out as it passes through water and does not reach the deep sea.

Plants are the "primary producers" in the ocean and form the first trophic level. Some are fleshy seaweeds or *limu*, some form hard skeletons similar to the structure created by coral and that help build the coral reef ("coralline algae"), some are single cells that live in the tissue of corals and provide energy to the corals ("zooxanthellae"), and some are microscopic single-celled plants that float in the ocean ("phytoplankton").

The "primary consumers" are "herbivores" (animals that feed only on plants). Primary consumers are the animals that eat algae, either phytoplankton or seaweed. They form the second trophic level.

"Secondary consumers" are "carnivores" (animals that eat other animals). Secondary consumers are the animals that eat the animals that eat algae. They form the third trophic level.

"Tertiary consumers" are predators on carnivores. They form the fourth trophic level.

You will be constructing food chains and webs that reflect these "trophic levels," the levels through which nutrients and energy flow, within a typical Hawaiian coral reef community.

Creating a Marine Food Chain

1) Read the cards provided.

2) Construct a food chain using some of the cards.
   a) On one sheet of paper, draw horizontal lines to indicate the first, second, third and fourth trophic levels. Designate one color to indicate the first trophic level (plants).
   b) Identify organisms on the cards that are in the various trophic levels.
   c) Tape a picture of one organism in each trophic level on the paper. Draw arrows from the plant or animal being eaten towards the animal doing the eating. These arrows represent the flow of energy between organisms. Use the designated color to draw the arrow to any animal eating a plant.

   ### Note
   A food chain is linear. For example: seaweed is eaten by snail, snail is eaten by crab, crab is eaten by fish, fish is eaten by shark.

3) At this point, your teacher will ask you to present your food chain to the class.

Creating a Marine Food Web

1) Dismantle your food chain and construct a marine food web using all of the cards.

2) On another large piece of paper draw horizontal lines to indicate four trophic levels, again designating one color to indicate the first trophic level (plants).

3) Place each card in a trophic level. Build the whole food web with the 20 cards before you tape down the cards. Add trophic levels if you need to do so.

Note

A food web is not linear, there may be multiple connections among organisms in a food web.

4) Draw arrows from the plant or animal being eaten towards the animal doing the eating. Again, use the designated color to connect plants to any animal eating them. There may be more than one animal eating a plant or animal. Show as many connections as you can.

5) There are two other categories having to do with an organism's role in cycling energy through an ecosystem:
   - "Detritivores" or scavengers are animals that feed on organic materials on the seafloor. "Detritus" refers to the remains of dead organisms or cast-off material from living organisms.
   - "Decomposers" are bacteria that break down organic material further, into its inorganic components, so it can be recycled back into the system.

   Using the above information, represent detritivores and decomposers on your food web (they won't necessarily fit into a trophic level). You may also wish to use the following information:

   - The black sea cucumber (*loli okuhi kuhi* or *Holothuria atra*) is an example of a detritivore. It lives in shallow water on sand.

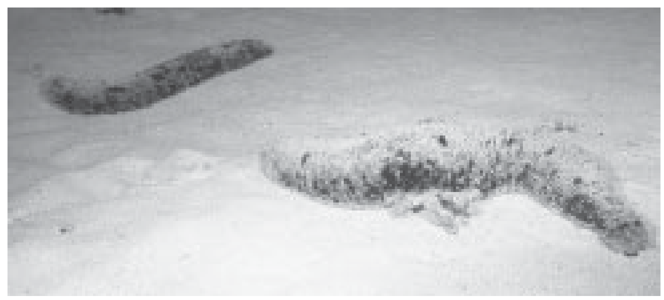


Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing*

   - The partridge tun snail (*pū'ōni'oni'o* or *Tonna perdix*), which is also found in shallow water and generally seen at night, feeds on sea cucumbers.

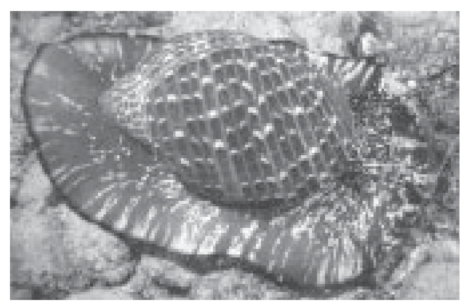


Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing*

6) Next, add a human to the food web. Draw the arrows to the human in a different color than you have used before. Which animal has the most links to it in the food web?

Poison Pathways

Ciguatera fish poisoning is an illness caused by eating seafood—mostly reef fishes—that have accumulated a poison called "ciguatoxin." Each year, about ten to twenty people in Hawai'i get ciguatera poisoning, the symptoms of which may last a week or so in mild cases. In some cases, the symptoms may persist for several months or longer.

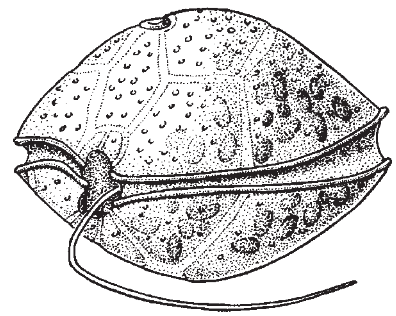
What does it feel like to have ciguatera fish poisoning? Your mouth, hands, and feet may go numb and tingly. Your joints and muscles might hurt, cramp up, or become weak. You could have chills, itching, headaches, sweating, dizziness, vomiting, or diarrhea. None of that is very pleasant—and your symptoms may range from mild to severe, beginning two to five hours after eating contaminated fish. There's another symptom that doesn't usually kick in until two to five days after eating a toxic fish. It's known as "temperature sensation reversal." Cold objects feel hot, and hot objects feel cold.

If ciguatera poisoning sounds like something you want to avoid, use these precautions:

- Do not eat the head, guts, or roe (eggs) of any reef fish. The ciguatoxin is concentrated up to 100 times in these parts of the fish, compared to other parts.
- Thoroughly clean reef fish as soon as possible after they are caught. This is to prevent the toxin that has accumulated in the organs from further contaminating the flesh.
- Remember that ciguatoxin is not destroyed by cooking, drying, salting, or freezing fish.
- Avoid eating fish caught at sites known to have a ciguatoxic algae problem.

Toxic Algae?

What is ciguatoxic algae? Ciguatoxin is produced by microscopic marine organisms called "dinoflagellates." Dinoflagellates of a particular species, *Gambierdiscus toxicus*, bloom among and on the algae on which herbivorous fish such as *kole* (gold-ring surgeonfish) and *palani* (eyestripe surgeonfish) feed. As they forage through the algae, these fish ingest the dinoflagellates and the ciguatoxin they produce. The algae itself is not toxic, but it may as well be.



Gambierdiscus toxicus *magnified approximately 400 times*
Image: The Epidemiology Branch, State of Hawai'i

Accumulating up the Food Chain

The ciguatoxin accumulates in the flesh and organs of herbivorous fish. When these fish are eaten by carnivorous fish, the toxin travels up the food chain, accumulating in the bodies of the carnivores as well. Through this process of "bioaccumulation," carnivores may end up with greater concentrations of ciguatoxin than herbivores because they may repeatedly eat animals with the toxin concentrated in their tissues.

Humans can be carnivores, too. When people eat toxic fish—either herbivorous or carnivorous fish—they are exposed to ciguatoxin. Depending on the individual's sensitivity and prior exposure to ciguatoxin, a person may become mildly to severely ill.

You can reduce your chances of a run-in with ciguatoxin by knowing how ciguatoxin fits in to Hawaiian marine food chains. Use the information on the next two pages to answer the questions that follow.

Fish Species to Watch Out For

Most incidents of ciguatera poisoning in Hawaiʻi have been caused by four types of fish: *ulua* (jack), *kāhala* (amberjack), *kole* (gold-ring surgeonfish), and *pōʻou* (ringtail wrasse). But other fish species have been implicated in incidents of ciguatera poisoning, too. Here is a list of these species, along with a brief description of what they eat. You will use this information to help you answer the questions that accompany this reading.

The Big Four

Ulua or Jack (*pāpio* = juvenile)

Caranx sexfasciatus (Bigeye jack), *Carangoides orthogrammus* (Yellowspotted jack), among others

Length: Maximum one meter (three feet), depending on the species

Feeding: These swift, strong-swimming predators, which frequent open water near dropoffs or over reefs, feed primarily on other fishes, and forage on the bottom for crustaceans and other invertebrates.

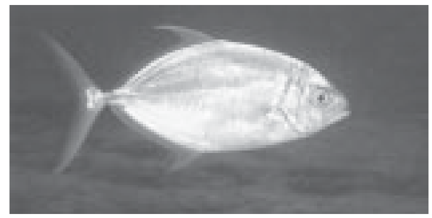


Photo: John P. Hoover

Kāhala or Amberjack

Seriola dumerili

Length: Up to two meters (six feet)

Feeding: These large predators occasionally come inshore to feed off schooling fishes in shallow water.

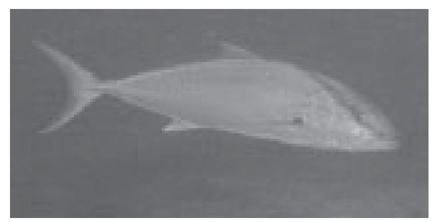


Photo: John P. Hoover

Kole or Gold-ring surgeonfish

Ctenochaetus strigosus

Length: Up to 17 centimeters (seven inches)

Feeding: Algae feeders

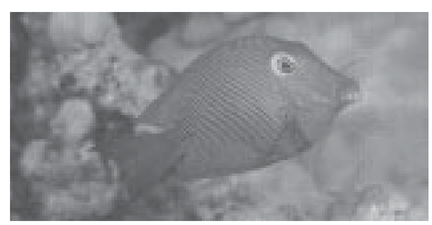


Photo: John P. Hoover

Pōʻou or Ringtail wrasse

Cheilinus unifasciatus

Length: Up to 45 centimeters (18 inches)

Feeding: Predators of fishes, they typically hover several feet off the bottom, head angled down, ready to strike.

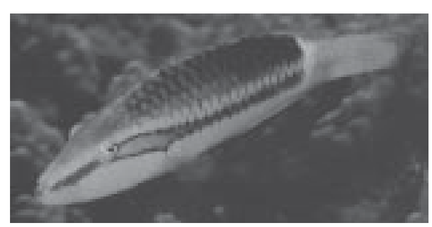


Photo: John P. Hoover

Other Species to Watch

ʻAmaʻama or Striped mullet
Mugil cephalus
Length: Up to 50 centimeters (20 inches)
Feeding: They feed primarily off the bottom, taking in sand or mud and filtering out the organic material through their gills.

Palani or Eyestripe surgeonfish
Acanthurus dussumieri
Length: Up to 45 centimeters (18 inches)
Feeding: These are algae feeders.

Kākū or Great barracuda
Sphyraena barracuda
Length: Up to two meters (six feet)
Feeding: These lean, fast, and powerful predators hunt in schools or alone and are often found in shallow water close to shore.

Uku or Gray snapper
Aprion virescens
Length: Up to one meter (three feet)
Feeding: These are long, powerful-looking, greenish to bluish gray predators.

Roi or Peacock grouper
Cephalopholis argus
Length: Up to about 40 centimeters (16 inches)
Feeding: These are large-mouthed, bottom-dwelling predators introduced from Moorea, French Polynesia in 1956. They rely on ambush or careful stalking to get within striking distance of their prey. When the prey is sufficiently close, the grouper opens its large expandable mouth and takes in water, along with its meal.

Weke or Goatfish
Mulloidichthys spp.
Length: Up to 60 centimeters (24 inches), depending on species
Feeding: They probe the sand with their whisker-like barbels, searching for worms, molluscs, and other invertebrates.

Pūhi or Moray eel
Gymnothorax flavimarginatus (Yellowmargin moray) and others
Length: Up to 2.5 meters (eight feet), depending on species
Feeding: These predators feed on fish and crustaceans.

Taʻape or Bluestripe snapper
Lutjanus kasmira
Length: Up to 37 centimeters (15 inches), but usually smaller
Feeding: These predators range from shallow water to deeper waters. Introduced from the Marquesas in 1958, they are low priced and compete with more favored food fish.

Wahanui or Forktail snapper
Aphareus furca
Length: Up to .3 meters (one foot)
Feeding: These predators typically scout the reef from a position well off the bottom, often near dropoffs.

ʻŪʻū or Soldierfish
Myripristis spp.
Length: Up to 27 centimeters (11 inches), depending on the species
Feeding: These medium-sized nocturnal fishes are usually red, with big scales and large dark eyes. They favor plankton in the water away from the bottom.

Sources
Epidemiology Branch, *Fish Poisoning in Hawaiʻi,* State of Hawaiʻi, Department of Health, Honolulu, 1997.

Hawaiʻi Department of Health, "Ciguatera Fish Poisoning" at <www.hawaii.gov/doh/resource/comm_dis/cddcigua.htm>.

Cigua-Check Fish Poison Test Kit website at <www.cigua.com>.

Shirai, J. L., L. K. Shirai, and Y. Hokama, *Seafood Poisoning: Ciguatera*, Yosh Hokama Family Trust, Gardena, California, 1991.

Poison Pathways: Questions from the Reading

1) Draw a food chain showing how a person could get ciguatera poisoning from eating an herbivorous fish. Use specific examples based on the reading.

2) Draw a food chain showing how a person could get ciguatera poisoning from eating a carnivorous fish. Use specific examples based on the reading.

3) *‘Ū‘ū* or soldierfish do not fit into the two categories of fish that become ciguatoxic: herbivores that graze on “toxic” algae, and carnivores that feed on toxic herbivores. *‘Ū‘ū* feed on plankton in midwater—away from the algae growth. Come up with one possible explanation for the fact that *‘ū‘ū* have been implicated in at least one case of ciguatera poisoning in Hawai‘i and describe it below in as much detail as you can. (You do not need to do additional research to formulate your explanation, but make sure you clearly explain your idea and your reasoning.)

Activity #3

Marine Life Scrapbooks

● ● ● In Advance *Assembling Research Resources*

You may want to pull together a reference collection for your classroom or to place on reserve in the library, prior to beginning this activity. See the "Resources for Further Research and Reading" list in the unit overview (p. 4) for suggested books and articles.

● ● ● Class Period One *Beginning the Scrapbooks*

Materials & Setup

For each student

- Student Page "Marine Life Scrapbooks" (pp. 40-41)

Instructions

1) Hand out the Student Page "Marine Life Scrapbooks." Explain to students that this is a starting point for researching and assembling a scrapbook on the natural history and cultural significance and use of Hawaiian marine plant and animal species.

2) You may have students work individually or allow small groups to work together.

3) Determine how long you will allow for students to complete this assignment, and let students know the due date. One week is a suitable length of time.

4) Allow students the rest of the class period to work on their scrapbook ideas. Have groups of students brainstorm ideas, and/or allow students to begin library and Internet research.

Journal Ideas

- Think of a marine plant or animal that is important to you or your family. Describe the significance of this organism to you.
- What kinds of information can you learn by listening to people's stories that you cannot learn from library or Internet research?

Assessment Tools

- Student scrapbooks
  - Use guidelines and rules on the Student Page "Marine Life Scrapbooks" as pointers for assessment.
  - Another assessment aid is the Teacher Background "Importance of Some Marine Species in Hawaiian Culture" (pp. 38-39) which includes brief notes about Hawaiian cultural significance from the sources recommended in the unit overview (p. 4).

Teacher Background

Importance of Some Marine Species in Hawaiian Culture

Since Hawaiian cultural significance of marine species was not covered in other activities in this unit, students may need more guidance in their research. This information is not as readily available in written form as information about biology and natural history. This list contains brief notes about a selection of marine species that are significant in traditional Hawaiian culture. The notes are taken from the books in the resource list on the Student Page “Marine Life Scrapbooks.” You may use this list to help guide student species selection, as well as to help assess cultural information in student scrapbooks.

Limu (Seaweeds)

Limu kala (*Sargassum echinocarpum*)
- ‘Loosens’ evil spirits causing illness
- Used in the ho’oponopono process and in the purification ceremony after the death of a relative
- Used for food

Limu kohu (*Asparagopsis taxiformis*)
- Used for food
- The subject of a legend
- Tended in gardens

Invertebrates

Kūpe‘e (Polished nerite, *Nerita polita*)
- Meat used for food
- Shell used for body ornaments

Leho ahi (Humpback cowry, *Cypraea mauritiana*)
- Meat used for food
- Shell used for food scrapers and octopus lures

‘Opihi (Hawaiian limpet, *Cellana* spp.)
- Meat used for food and medicine
- Shell used for scooping, peeling, scraping

He‘e (Octopus, *Octopus* spp.)
- Used for food

Wana (Long-spined sea urchin, *Echinothrix calamaris* and *diadema*)
- Used for food

Vertebrates

Manō (Sharks)
(Tiger shark *Galeocerdo cuvier,* Whitetip reef shark *Triaenodon obesus*, Gray reef shark *Carcharhinus amblyrhynchas*, and others)
- Found in Hawaiian proverbs
- Teeth used as the cutting edge on weapons
- Skin used for drumheads
- Various Hawaiian gods associated with sharks

‘Ahi (Yellowfin tuna, *Thunnus albacares*)
- Sportfishing for chiefs
- Used for food, often dried for later use

Āholehole (Hawaiian flagtail, *Kuhlia sandvicensis*)
- A favored food of chiefs
- Used in ceremonies

Akule (Bigeye scad, *Selar crumenophthalmus*)
- Used for food, a favorite for drying

‘Ama‘ama (Striped mullet, *Mugil cephalus*)
- Used for food
- Featured in legends

ʻĀweoweo (Hawaiian bigeye, *Priacanthus meeki*)
- Used for food
- Found in stories

Kūmū (Whitesaddle goatfish, *Parupeneus porphyreus*)
- Used for food
- Offered to the gods

Manini (Convict tang, *Acanthurus triostegus*)
- Used for food

Moi (Six-fingered threadfin, *Polydactylus sexfilis*)
- Used for food

Mū (Bigeye emperor, *Monotaxis grandoculis*)
- Used for food
- Check other uses of the name, *mū*, for an interesting connection.

Palani (Eyestripe surgeonfish, *Acanthurus dussumieri*)
- Used for food
- Featured in a legend

Pūhi (Moray eels, including Yellowmargin moray eel, *Gymnothorax flavimarginatus,* and others)
- Used for food
- Captured using a variety of fishing methods

Uhu (Parrotfishes, including Bullethead parrotfish, *Chlorurus sordidus,* Palenose parrotfish, *Scarus psittacus,* Spectacled parrotfish, *Scarus perspicillatus,* and others)
- Used for food
- Captured using a variety of fishing methods
- Appear in legends

Marine Life Scrapbooks

Your assignment is to make a scrapbook about Hawaiian marine plant and animal species. Your scrapbook will include a summary of what you have learned about these species as well as more information based on research.

Guidelines for Your Scrapbook

1) Include three or more different marine species, using at least one page for each species.

2) For each species, include the following information:
   - All of the names for this species you can find, including scientific, common, Hawaiian, and other languages
   - A summary of the biology and natural history of this species
     (The summary for each species should include information about its trophic level, relationships with other marine organisms, habitat, and adaptations.)
   - Information about the cultural significance and uses of this species
     (You do not need to limit this information to the traditional Hawaiian significance and uses of these species. Other cultures that have been important in creating the modern Hawaiian culture and society may also attach significance to these species and use them in different ways.)
   - Drawings or photographs of the species and other images that help convey what you have learned about this species

Ideas

- Use species you studied in this unit or species that are significant to you or members of your family, or start by looking at "Marine Species Important in Hawaiian Culture" below as a starting point. It lists many marine species that are important in traditional Hawaiian culture.

- Research the natural history and cultural significance of plants and animals by doing library or Internet research. As you find information, add it to your scrapbook. See the "Resources List" below for suggested starting points.

- Look for stories or legends having to do with marine species.

- Ask family members and friends (especially *kūpuna*) for information, stories, recipes, or any sort of personal experiences that they have with the species.

- Include your own personal experiences in the scrapbook.

- If you find a good "informant," you may audio- or videotape that person, in addition to taking notes. This can become part of your scrapbook, too.

Marine Species Important in Hawaiian Culture

Limu (Seaweeds)

- *Limu kala* (*Sargassum echinocarpum*)
- *Limu kohu* (*Asparagopsis taxiformis*)

Invertebrates

- *Kūpe‘e* (Polished nerite, *Nerita polita*)
- *Leho ahi* (Humpback cowry, *Cypraea mauritiana*)
- *‘Opihi* (Hawaiian limpet, *Cellana* spp.)
- *He‘e* (Octopus, *Octopus* spp.)
- *Wana* (Long-spined sea urchin, *Echinothrix calamaris* and *diadema*)

Vertebrates

- *Manō* (Sharks)
  (Tiger shark *Galeocerdo cuvier,* Whitetip reef shark *Triaenodon obesus*, Gray reef shark *Carcharhinus amblyrhynchas*, and others)
- *‘Ahi* (Yellowfin tuna, *Thunnus albacares*)
- *Āholehole* (Hawaiian flagtail, *Kuhlia sandvicensis*)
- *Akule* (Bigeye scad, *Selar crumenophthalmus*)
- *‘Ama‘ama* (Striped mullet, *Mugil cephalus*)
- *‘Āweoweo* (Hawaiian Bigeye, *Priacanthus meeki*)
- *Kūmū* (Whitesaddle goatfish, *Parupeneus porphyreus*)
- *Manini* (Convict tang, *Acanthurus triostegus*)
- *Moi* (Six-fingered threadfin, *Polydactylus sexfilis*)
- *Mū* (Bigeye emperor, *Monotaxis grandoculis*)
- *Palani* (Eyestripe surgeonfish, *Acanthurus dussumieri*)
- *Pūhi* (Moray eels, including Yellowmargin moray eel *Gymnothorax flavimarginatus* and others)
- *Uhu* (Parrotfishes, including Bullethead parrotfish *Chlorurus sordidus,* Palenose parrotfish *Scarus psittacus,* Spectacled parrotfish, *Scarus perspicillatus,* and others)

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