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.

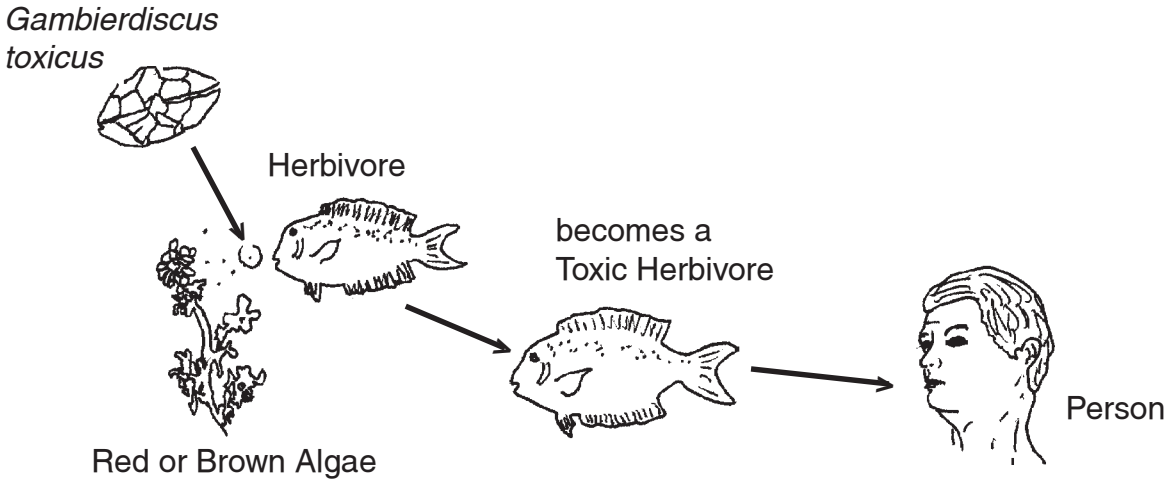


Image after J. L. Shirai, L. K. Shirai, and Y. Hokama, Seafood Poisoning: Ciguatera*, Yosh Hokama Family Trust, Gardena, California, 1991*

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

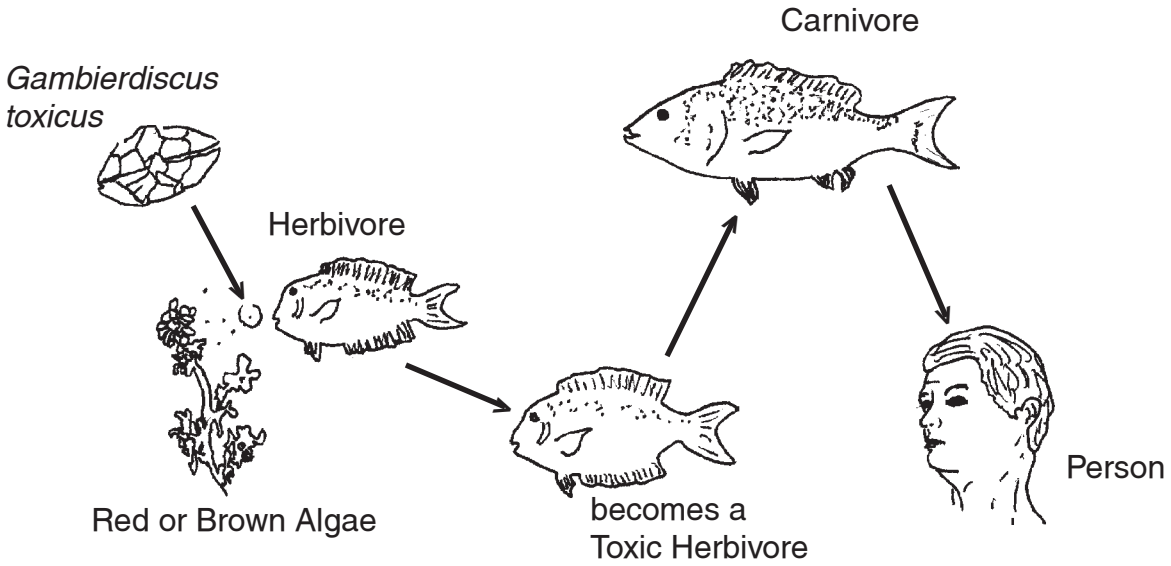


Image after J. L. Shirai, L. K. Shirai, and Y. Hokama, Seafood Poisoning: Ciguatera*, Yosh Hokama Family Trust, Gardena, California, 1991*

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

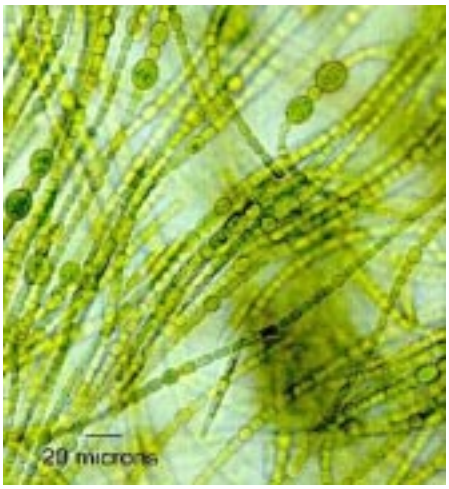


Photo: Roger Burks (University of California, Riverside), Mark Schneegurt (Wichita State University), Cyanosite (www-cyanosite.bio.purdue.edu/index.html)

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.

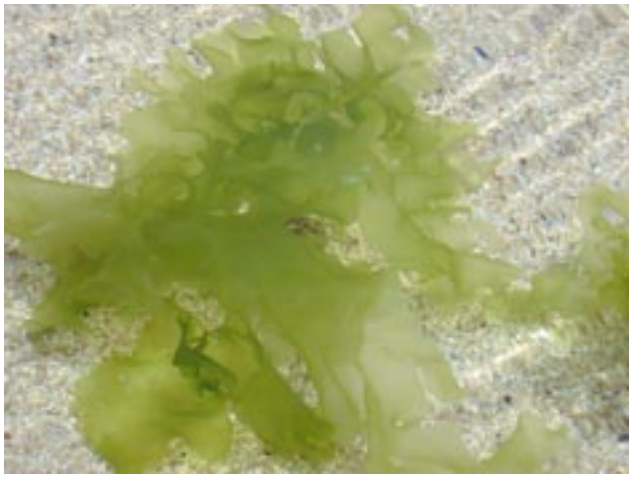


Photo: Kim Martz and Forest Starr

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.

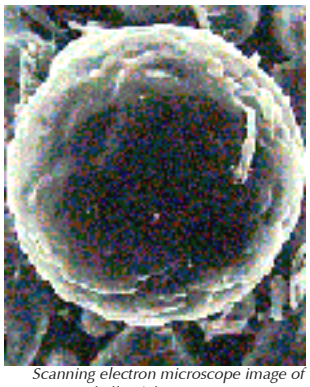
Photo: Karl Embleton, Sir Alister Hardy Foundation for Ocean Sciences

Zooplankton

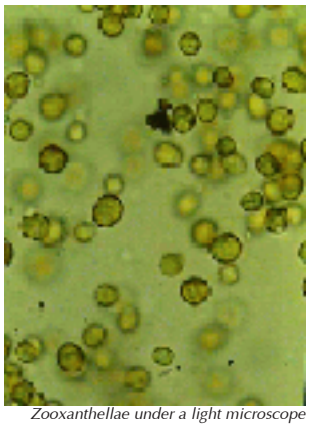
Most are tiny animals floating in the water, but some are larger, like jellyfish. The smallest ones feed on phytoplankton; larger ones eat smaller zooplankton.

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

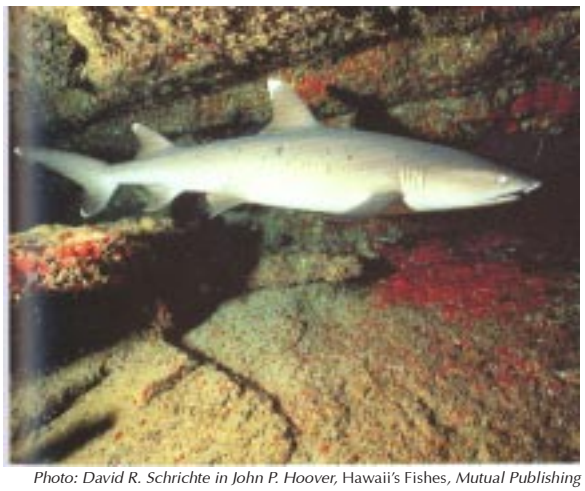


Photo: David R. Schrichte in John P. Hoover, Hawaii's Fishes, *Mutual Publishing*

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, Hawai'i'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.

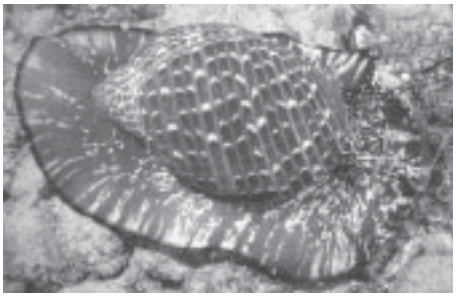


Photo: John P. Hoover, Hawai'i's Sea Creatures, *Mutual Publishing*

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.

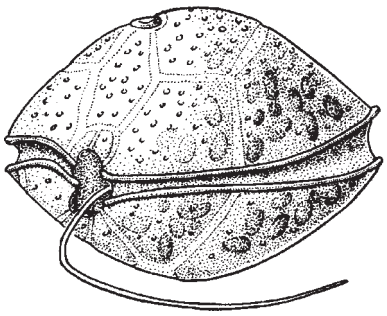
What does it feel like to have ciguatera fish poisoning? Your mouth, hands, and feet may go numb and tingly. Your joints and muscles might hurt, cramp up, or become weak. You could have chills, itching, headaches, sweating, dizziness, vomiting, or diarrhea. None of that is very pleasant—and your symptoms 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* (goldring 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 Hawai‘i have been caused by four types of fish: *ulua* (jack), *kāhala* (amberjack), *kole* (gold-ring surgeonfish), and *pō‘ou* (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.

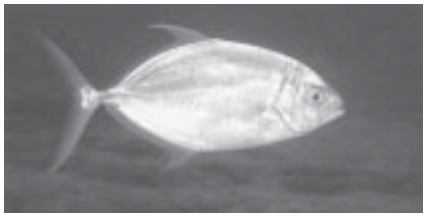


Photo: John P. Hoover

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

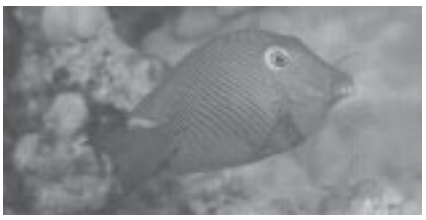


Photo: John P. Hoover

Pō‘ou 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) *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.)