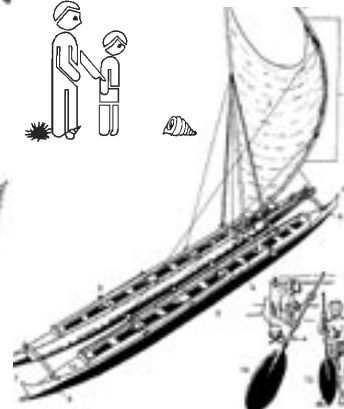
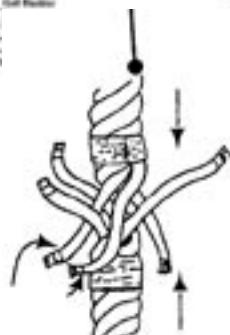
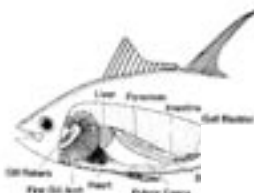
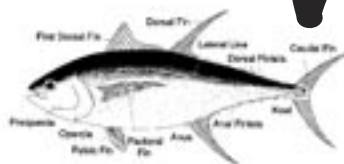
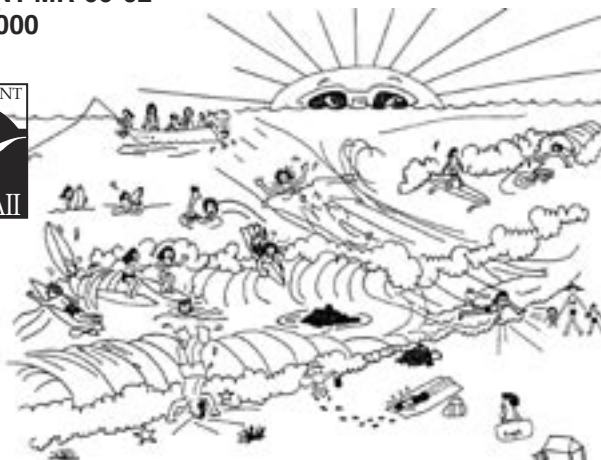


Marine Activity Workbook



University of Hawaii Sea Grant College Program
School of Ocean and Earth Science and Technology
UNIH-SEAGRANT-MR-99-02
April 2000





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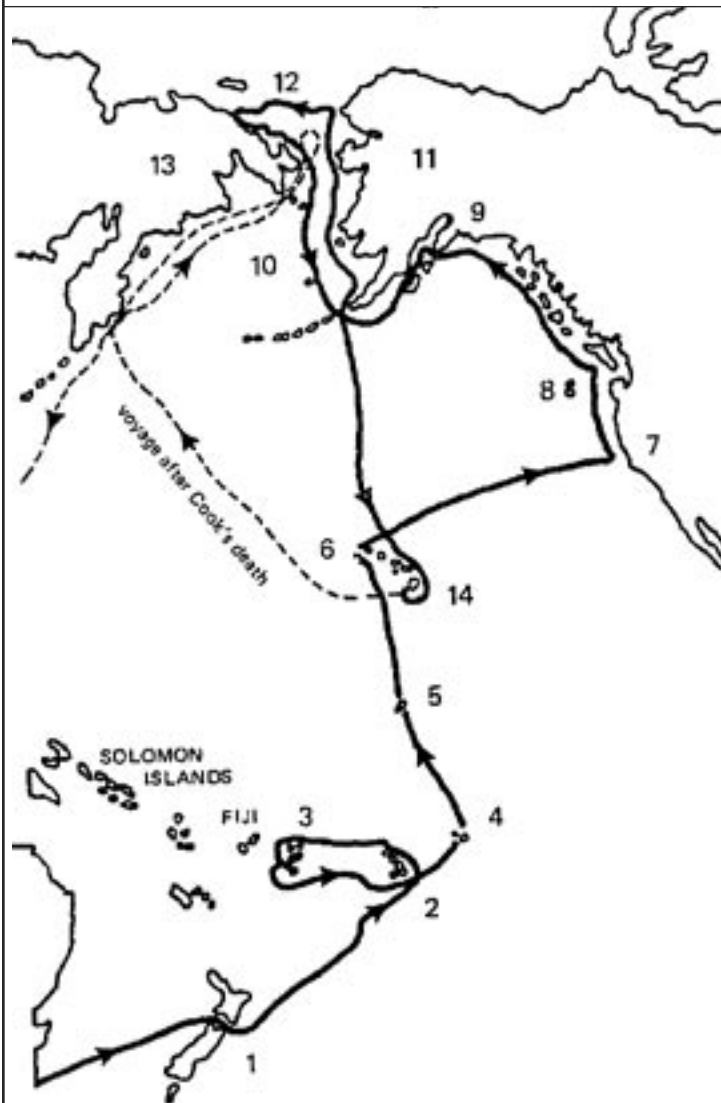
Cook's Voyage

1

Below is a map of the Pacific Ocean and the route of Captain Cook's third voyage. It was on this voyage that he discovered Hawaii.

DIRECTIONS: Fill in the **Map Key** using the names from the **List of Places**.
(Answers on page 25.)

List of Places:	Christmas Island	Kauai	Hawaii	Bering Sea
	New Zealand	Siberia	Alaska	Cook Inlet
	Vancouver Island	Arctic Ice	Tahiti	Cook Islands
	Friendly Islands	New Albion		



Map key:

1. _____
2. _____ Islands
3. _____ Islands
4. _____
5. _____ Island
6. _____
7. _____
8. _____ Island
9. _____
10. _____ Sea
11. _____
12. _____
13. _____
14. _____

Maritime History of Hawaii

2

This is a brief maritime history of Hawaii.

Directions: Place the missing events listed below in the timeline by writing the matching letter in the square. Use the letters in the list below. (Answers on page 25.)

Missing events:

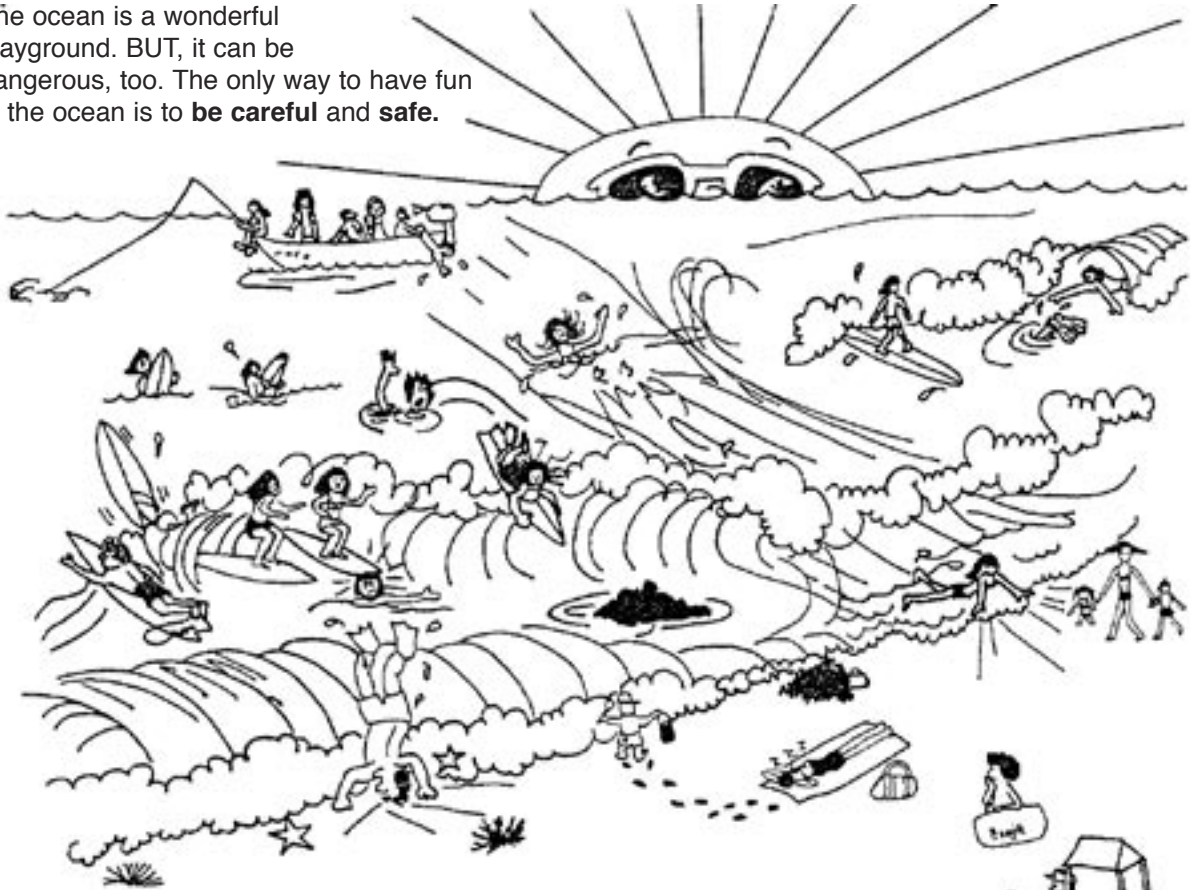
- | | |
|---------------------------------------|--|
| A. Captain Cook sails into Hawaii. | E. First missionaries arrive in Hawaii. |
| B. Aloha Tower built. | F. Falls of Clyde built. |
| C. Worst tsunami in Hawaii history. | G. Hokuleia sails 6,000 miles to Tahiti. |
| D. First lighthouse built at Lahaina. | H. Early Polynesians settle in Hawaii. |

-
- | | | |
|-----------------|--------------------------|--|
| Before 100 A.D. | <input type="checkbox"/> | |
| 1550 | | Possible landings of Spanish during trading expeditions to the East Indies. |
| 1778 | <input type="checkbox"/> | |
| 1819 | | Kamehameha I, the first Hawaiian king to unite all the islands, dies at age 60.
Whaling Era begins as one whale is killed off the coast of Hawaii. |
| 1820 | <input type="checkbox"/> | |
| | | Kamehameha II (Liholiho) purchases Cleopatra's Barge for \$90,000 and renames her Haaheo o Hawaii. |
| 1840 | <input type="checkbox"/> | |
| 1846 | | Peak of the whaling industry with the arrival of 596 whalers in Hawaiian ports. |
| 1865 | | Arrival of first Chinese immigrants. |
| 1878 | <input type="checkbox"/> | |
| 1899 | | Nakasugi, the father of commercial fishing in Hawaii, arrives in Honolulu with the first sampan. |
| 1900 | | First fish auction held in Honolulu. |
| 1925 | <input type="checkbox"/> | |
| 1936 | | First transpacific passenger air service to Hawaii. |
| 1941 | | Japanese forces attack Pearl Harbor. |
| 1946 | <input type="checkbox"/> | |
| 1949 | | Worst maritime strike in Hawaiian history (178 days). |
| 1973 | | Polynesian Voyaging Society established to research means by which
Polynesian seafarers found and settled nearly every inhabitable island in the
Polynesian Triangle. |
| 1976 | <input type="checkbox"/> | |
| 1980 | | Nainoa Thompson becomes the first Hawaiian navigator in over 500 years to
guide a canoe from Hawaii to Tahiti and back. |
| 1985 | | The Voyage of Rediscovery begins as the Hokuleia sails 16,000 miles along the
ancient migratory routes of the Polynesian Triangle showing that it was possible
for Polynesians to travel over 10-million square miles of the Pacific during a
period of over 1,000 years using non-instrument navigation. |
| 1992 | | Micronesian Mau Piailug, Hokuleia's 1976 navigator, teaches Hawaiians the
ancient art of canoe building using stone adzes. |
| 1994 | | The Polynesian Voyaging Society establishes the Exploration Learning Center. |

Ways to Have Fun in the Ocean

3

The ocean is a wonderful playground. BUT, it can be dangerous, too. The only way to have fun in the ocean is to **be careful** and **safe**.



Here are some **safe** things to do. Draw a **green line** from each safe act to its matching picture.

- asking lifeguards about the water
- wearing a surfboard leash
- supervising children
- diving under a breaking wave
- surfing ahead of the curl, not straight into shore
- staying out of the water if the waves look too big for you



Here are some ocean dangers. Draw a red line from each danger to its matching picture.

- unsupervised child
- swimmer caught in rip
- loose surfboard
- going "over the falls"
- crowded wave
- rocks

The next time you go to the beach, look out for these dangers!

The world's oceans, especially near the equator, are like your hot water tank at home. The sun's energy, stored in the warm ocean surface, could be tapped by a process called ocean thermal energy conversion (OTEC). The idea was first suggested 100 years ago by a Frenchman, Arsene d'Arsonval. His student, George Claude, actually tested OTEC plants in the 1930s. However, for forty years, not much more was done until the 1970s when everyone worried about the "energy crisis." Today, energy planners think OTEC is an important source of energy.

There is no question that the world is slowly running out of oil. Some energy experts believe the "oil age" will die out in another 30 years or so—within one generation. The question is what will Hawaii turn to after oil? Coal? Nuclear? Solar?

There are many choices of renewable energy sources for Hawaii—wind, biomass, photovoltaic cells, solar heaters. OTEC is one possibility that could some day provide much of our electricity and other energy needs. One medium-sized plant could provide electricity for about 4,000 people. OTEC could be used to produce methanol or ammonia as a substitute for gasoline. The cold water from an OTEC plant could be recycled for producing fish and other seafood.

OTEC works like a modern powerplant. In the Kahe plant, water is turned into steam in a boiler by burning oil. The steam turns a turbine which runs a generator to produce electricity. Then the steam is changed back into water in a condenser which uses cold seawater to cool the steam.

DEEP OCEAN WATER SYSTEM

OTEC is based on utilizing the temperature differential between warm surface and cold deep ocean water to drive turbines. Three OTEC experiments were undertaken at the Natural Energy Laboratory of Hawaii Authority (NELHA). The mini-OTEC project in 1978 demonstrated the feasibility of OTEC. In 1997 an Open Cycle plant produced 100 KW. And a One MW Closed Cycle plant was under construction in 1999.

COLD UTILIZATION SYSTEM

(7-10 degrees Centigrade)

Subsystems using only cold deep ocean water (DOW) pumped from a depth of 2,000 feet include air-conditioning and industrial cooling, desalinization, fresh water production from condensate, and agriculture.

Cooling: NELHA buildings are cooled with DOW, thereby saving as much as \$4,000 per month in electricity. Common Heritage Corporation (CHC) uses a similar method for cooling its chlorohy.

Desalinization: The CHC and Oceanit Laboratories have a patent on a desalinization device called a Hurricane Tower. This "rain-maker" simulates a hurricane, creating vapor from warm surface ocean water at the bottom of the tower and condensing it with cold DOW at the top. Installed at the CHC facility in 1996, the model demonstrated the validity of the fundamental principle.

Fresh water production: Condensate is generated as DOW flows through pipes above ground in warm coastal environments. Condensate can be generated at an estimated rate of about 5% of the flow of cold water. A flow of 20,000 gallons per minute of DOW generates an estimated 1,000 gallons per minute of fresh water through simple condensation.

5

The diagram illustrates the integrated system for coldwater aquaculture and agriculture, showing the flow of water and the components involved.

Water Flow and Temperature:

- Desalination:** A circular process that takes in **Cold 4°C** water and **Warm surface** water.
- Air Conditioning (Office):** A rectangular box that receives water from the Desalination process.
- Industrial Cooling:** A rectangular box that receives water from the Air Conditioning process.
- Agriculture*:** A large rectangular box on the left that receives water from the Industrial Cooling process. It contains a list of crops: **Cold bed**, **Organic garden**, **Wide range of temperate climate**, and **Tropical vegetables and fruits**.
- Cold bed lawn irrigated by:** A central rectangular box that receives water from the Agriculture* box.
- Experimental plots*:** Two rectangular boxes at the bottom that receive water from the Cold bed lawn irrigated by box.
- Coldwater Aquaculture:** A large rectangular box on the right that receives **Warm Sea water** from the Desalination process. It contains two circular components: **Sea animals** and **Sea vegetables**.

Water Flow Arrows:

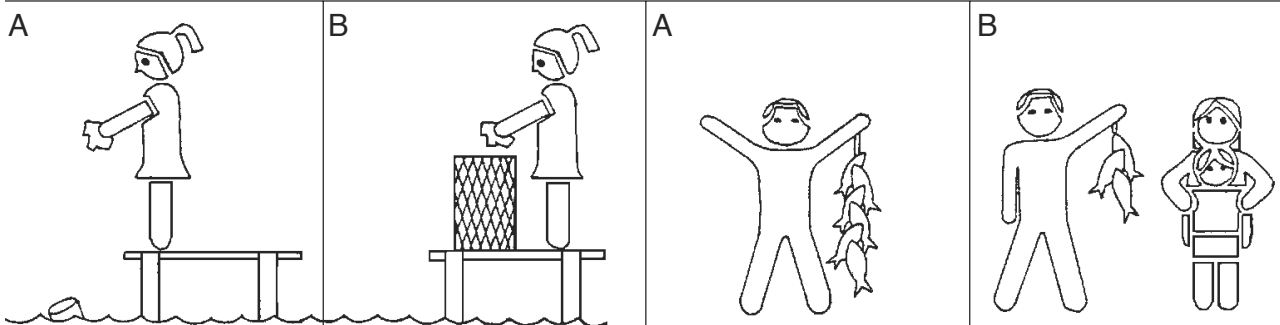
- From **Desalination** to **Air Conditioning (Office)**.
- From **Air Conditioning (Office)** to **Industrial Cooling**.
- From **Industrial Cooling** to **Agriculture***.
- From **Agriculture*** to **Cold bed lawn irrigated by**.
- From **Cold bed lawn irrigated by** to **Experimental plots***.
- From **Desalination** to **Coldwater Aquaculture** (labeled **Warm Sea water**).
- From **Coldwater Aquaculture** to the right (output).

For more information contact Common
Heritage Corporation, [http://www.aloha.com/
~craven](http://www.aloha.com/~craven).

Shoreline Conservation

6

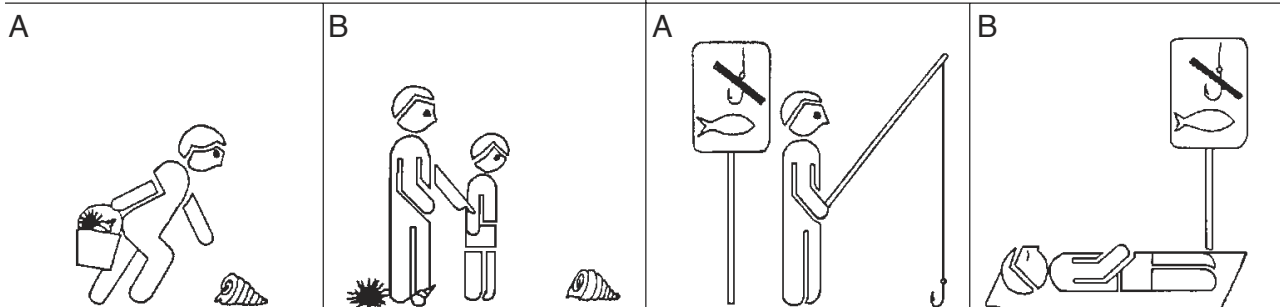
What does seashore conservation mean? It means the careful use of our shoreline resources. It means obeying rules to help keep plants and animals alive. It means taking only what you need and not more. What can **you** do to help conserve our resources? In the six sets of drawings below, choose the ones that show things that you can do to help conserve. Write A or B in the boxes below each set.



Put litter in its place.

☐

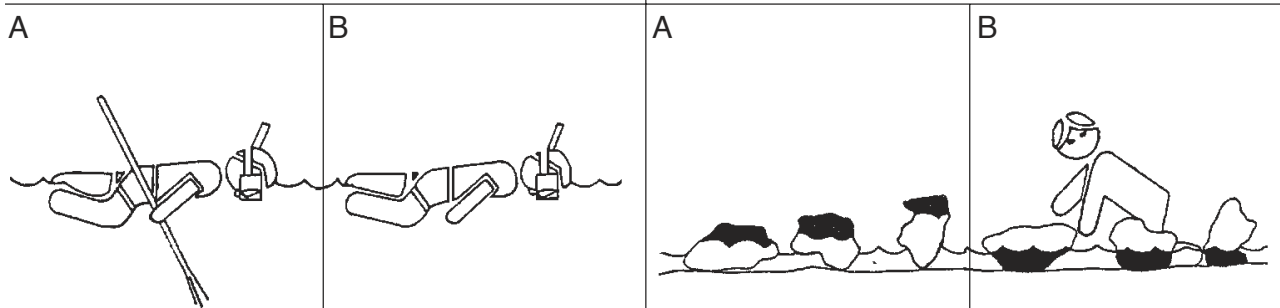
Catch only what you need.

☐


Do not collect everything in sight.

☐

Follow posted conservation signs.

☐


Do not spear lobsters out of season.

☐

Replace overturned rocks.

☐

Knots

7

Overhand knot



Square knot



Note: This is **not** a square knot!



Bowline knot



an "end-of-the-line" knot

Note: A square knot will reduce the strength of the line joined by 50%, a bowline by 30-40%, and a splice by only 10%.

Clove hitch



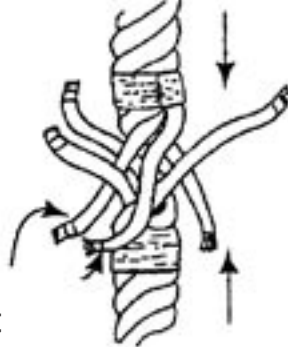
two half-hitches



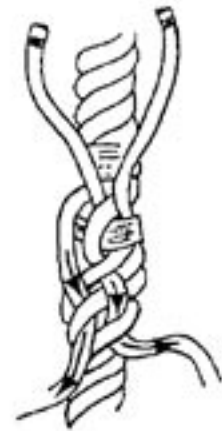
Sheet bend:
start with
a loop



Splicing



1) "Marry" the two ends to be spliced.



2) Weave the ends in and out of the partially unlayed line.

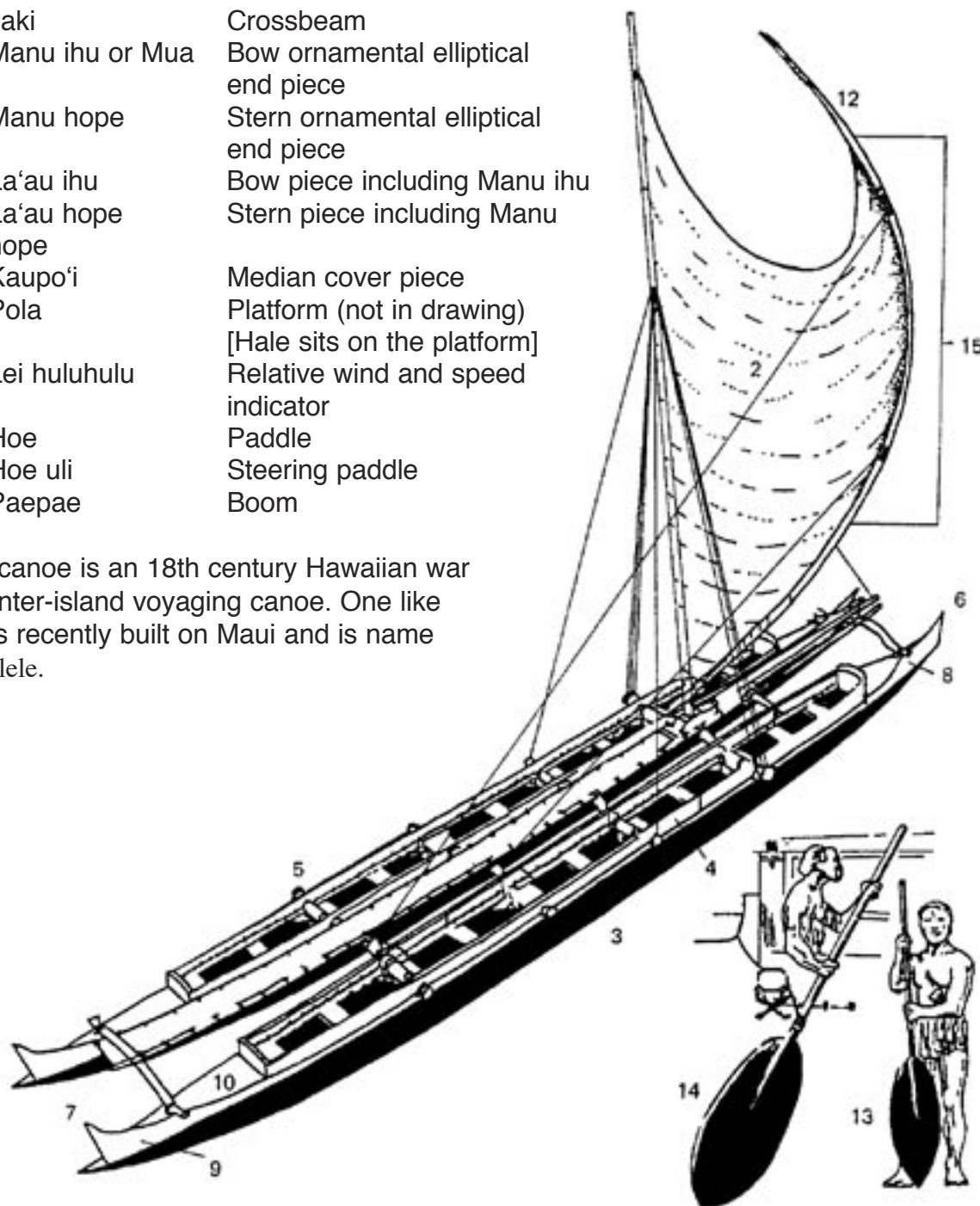
tape to prevent fraying

Wa'a Kaulua

8

- | | |
|--------------------|--|
| 1. Kia | Mast |
| 2. La or pe'a | Sail |
| 3. Kuamo'o | Hull |
| 4. Mo'o | Gunwale |
| 5. 'Iaki | Crossbeam |
| 6. Manu ihu or Mua | Bow ornamental elliptical end piece |
| 7. Manu hope | Stern ornamental elliptical end piece |
| 8. La'au ihu | Bow piece including Manu ihu |
| 9. La'au hope | Stern piece including Manu hope |
| 10. Kaupo'i | Median cover piece |
| 11. Pola | Platform (not in drawing)
[Hale sits on the platform] |
| 12. Lei huluhulu | Relative wind and speed indicator |
| 13. Hoe | Paddle |
| 14. Hoe uli | Steering paddle |
| 15. Paepae | Boom |

This canoe is an 18th century Hawaiian war and inter-island voyaging canoe. One like it was recently built on Maui and is name Mo'olele.

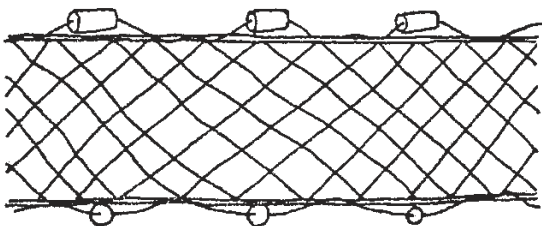


Fishing in Old Hawaii

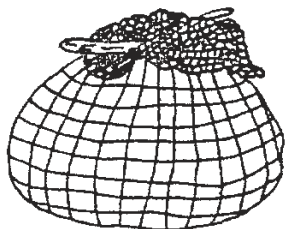
9

Draw a line connecting the animal with the proper fishing tool.

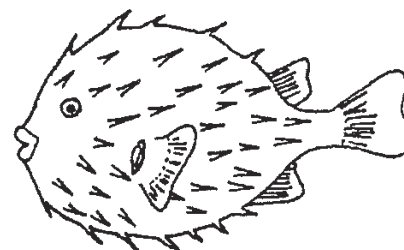
1. 'upena ku'u



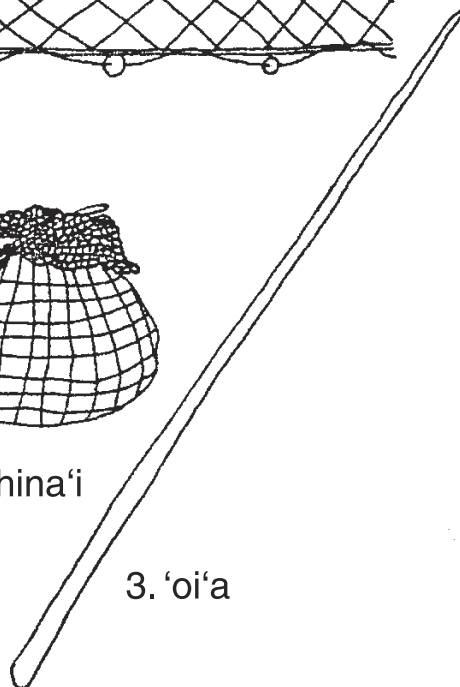
a. he'e



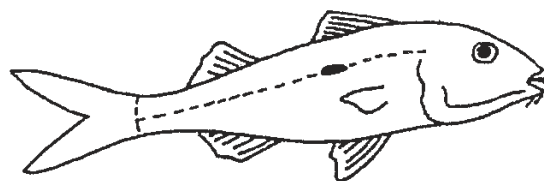
2. hina'i



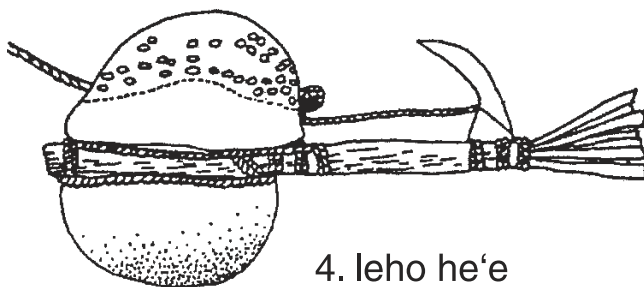
b. 'opu hue



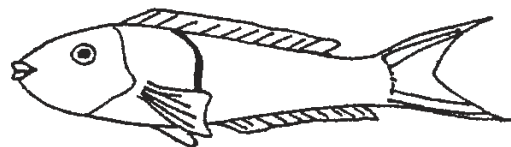
3. 'oi'a



c. weke 'a'a



4. leho he'e



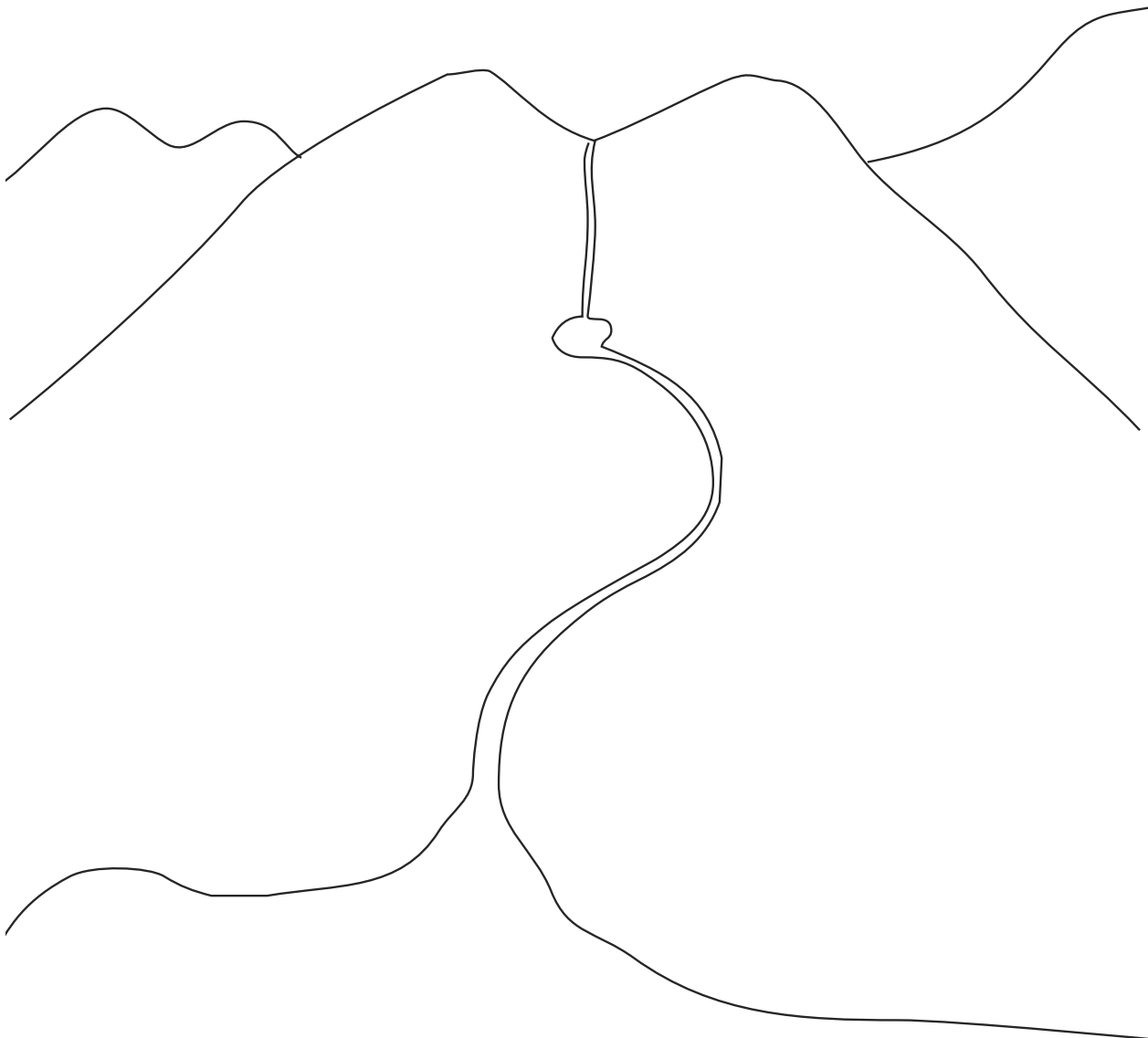
d. hinalea

Ahupua'a

10

This is a picture of an ahupua'a* on Oahu before people came to live in it. What did people add to the ahupua'a? Imagine that you are on a boat at sea. Fill in the ahupua'a so that it looks like a typical valley in which people live today.

*Land section, usually extending from the upland to the sea.



How Does Coral Grow?

11

A coral reef is one of the world's most complex communities of organisms. The most important member of the community is the coral polyp, which is responsible for making the skeletal material of calcium carbonate that accumulates into the structure called a coral reef. Worldwide, there are several thousand species of corals. Not all species of corals contribute to the building of coral reefs, and some corals do not produce a skeleton of calcium carbonate. Some organisms closely related to corals also secrete a skeleton of calcium carbonate and contribute to the reef structure.

The growth of massive mound-shaped corals and strong branching corals, together with many less robust species, produces the framework of the reef. When the polyps die, the skeletal remains are cemented together by a special algae called coralline algae. These algae also produce calcium carbonate. The coral skeleton covered with coralline algae then provides a hard surface for a new coral polyp to grow.

Only the top layer of the reef consists of living corals. Under the top layer are the remains of centuries of coral growth and death. This sequence gives rise to the upward and outward accumulation of coral skeletons that produce the reef.

The polyp is a simple animal. A ring of tentacles surrounds a mouth that leads to a single body cavity for digestion. The tentacles have special cells called nematocyst, which have little harpoons that can deliver a small dose of toxin for capturing prey.

The tentacles extend from the skeletal cup called a corallite when the polyp is feeding and retract when danger is present. The polyp has three body layers—an outer layer of epidermis, a layer of jelly-like material called mesoglea, and an inner layer of gastrodermis lining the body cavity. Living in the gastrodermis of reef building corals are minute algae called zooxanthellae. The zooxanthellae help the polyps in the production of their skeleton and also provide some nutrients for the polyps. Without the zooxanthellae the corals would not be able to produce the massive quantities of calcium carbonate that form the reef. Some coral polyps live solitary lives and can grow to 25 cm in size.



Most, however, live in colonies and are no more than 1 to 3 cm in size. The variety of growth forms in reef building corals leads to the many different shapes of the colonies. Some coral colonies can grow to be enormous as a result of asexual reproduction. Polyps can also reproduce sexually, producing a free swimming larva that will settle and form a new coral colony.

Reef building corals need shallow, clear, warm, and sunlit sea waters. This is why coral reefs are found only in the tropical and subtropical regions away from the influence of continental sediments and cool nutrient-rich upwellings. The movement of oceanic plates, which causes islands to sink, produces three major types of reefs. They are called fringing, barrier, and atoll. A fringing reef grows up to the land mass. A barrier reef is separated from the land mass by a lagoon. An atoll is formed when the island has sunk below the ocean's surface, leaving a reef surrounding a central lagoon. A small reef that grows up from the lagoon floor of an atoll or barrier reef is called a patch reef.

—Fagatele Bay National Marine Sanctuary
Summer Program Course Activities

Is life found at all depths in the ocean?

Some scientists believed, as recently as 1860, that marine life could not exist below 1,800 feet. That view was altered when a telegraph cable laid on the ocean bottom at 6,000 feet deep was retrieved and found covered with many forms of marine life.

How many fish species are there?

The most oft-quoted estimate is 20,000. There may be as many as 20,000 more.

What is the world's largest fish?

The smallest?

The largest is the whale shark, which grows to more than 50 feet in length and may weigh several tons. Second largest is the basking shark, which measures 35 to 40 feet long. The smallest fish is the tiny goby, an inhabitant of fresh to brackish water lakes in Luzon, Philippines. It is seldom longer than a half inch in adulthood, yet is so abundant that it supports a fishery.

How do you determine the age of the fish?

Mainly by two methods. Growth rings on scales and or ringlike structures found in otoliths (small bones of the inner ear) are examined and counted. The rings correspond to seasonal changes in the environment and can be compared to the annual rings of tree trunks. A series of fine rings are laid down in scales for each year of life—in summer, the rings grow faster and have relatively wide separations. In winter, slower growth is indicated by narrow separations between rings. Each pair of rings indicates one year. Because scale rings are sometimes influenced by other factors, scientists often use otoliths.

How long do fish live?

A few weeks or months (some of the small reef fishes) to 50 years or more (sturgeons). Longevity information is still sparse, but scientists have learned that species live 10 to 20 years in temperate waters.

Do fish breathe air?

Yes, but not directly into the lungs as mammals do (except for some tropical fish). As water passes over a system of extremely fine gill membranes, fish absorb the water's oxygen

content. Gills contain a network of fine blood vessels (capillaries) that take up the oxygen and diffuse it through the membranes.

Can fish swim backwards?

A number can, but usually don't. Those that can are mostly members of one of the eel families.

Do fish chew their food?

Not in the human manner. Carnivorous fish use their sharp teeth to seize and hold prey while swallowing it whole or in large pieces. Bottom dwellers such as rays are equipped with large, flat teeth that crush the shellfish they consume. Herbivorous fish (grazers) often lack jaw teeth, but have tooth-like grinding mills in their throats, called pharyngeal teeth. Fish would suffocate if they tried to chew because chewing would interfere with the passage of water over the gills, necessary for obtaining oxygen.

How many kinds of tuna are there and which kind makes up the biggest catch?

There are several commercial and sport-caught tunas, as well as several related species. They are all members of the scombrid family. Commercially caught tunas consist of albacore, bigeye, blackfin, bluefin, bonito, skipjack, and yellowfin.

Do tuna have scales?

Yes, all species do but their scales are so small over most of the body that they are nearly invisible. Prominent scaling appears only around the head, on the cheeks, and in the triangular area on each side of the body near the head.

How do porcupine fish inflate themselves?

All puffer-like fish inflate by pumping water into special sacs when in their natural environment. Out of water, a puffer fills the sacs with air instead, and takes on a balloon-like appearance.

What fishes are named after other animals?

Many are named after animals—alligator, bird, boar, buffalo, cat, cow, dog, elephant, frog, goat, goose, hawk, horse, leopard, lizard, parrot, porcupine, rabbit, sheep, squirrel, tiger, toad,

unicorn, viper, wolf, and zebra.

What attracts sharks? Which are most dangerous?

Considerable research has been devoted to finding out what stimuli attract sharks and incite them to attack. Results are mostly inconclusive, but some general principles have been advanced. Certain types of irregular sounds—like those made by a swimmer in trouble or a damaged fish—seem to attract sharks from great distances. Sound, rather than sight or smell, seems to be a shark's primary cue for moving into an area. Some scientific experiments indicate that sharks can distinguish light colors from dark and they may even be able to distinguish colors. Yellow, white, and silver seem to attract sharks. Many divers maintain that clothing, fins, and tanks should be painted in dull colors to avoid shark attacks. Though blood itself may not attract sharks, its presence in combination with other unusual factors will excite the animals and make them more prone to attack.

The most dangerous species in order of documented attack records are the great white shark, bull shark, tiger shark, grey nurse shark, lemon shark, blue shark, whale shark, sand tiger, several species of hammerheads, and the mako. Some species such as the nurse shark are extremely sluggish and have poorly developed teeth, but even these have been known to attack man when excited or disturbed.

What other sea creatures may be dangerous to swimmers?

The barracuda (although divers claim its ferocious reputation is undeserved), moral eel, octopus, and sharp-spined sea urchin can be dangerous to swimmers. The Portuguese man-of-war has tentacles up to 50 feet long with specialized cells that produce painful stings and welts on contact by swimmers. Stingrays, toadfish, catfish, and jellyfish can inflict damage on swimmers and waders. Certain coral reef organisms are to be avoided by divers.

Can crabs swim?

Most crabs "walk" or run across the ocean bottom. Some, such as the commercially caught

blue crab of the Atlantic coast (a member of the "swimming" crab family) can swim. Their rear-most pair of legs is modified for swimming and legs are paddle shaped.

How do crabs grow?

By shedding their outgrown shell. The rigid shell imprisons the crab and limits its growth. Once the shell is shed, the crab can absorb water and expand into its new-grown shell.

How do prawns, crayfish, and shrimp differ?

As so often happens, common names are used loosely and inconsistently in the shrimp family. The "prawn" of Great Britain and other countries is essentially the same animal as the shrimp of the U.S. In this country, the term "shrimp" applies to all crustaceans of the Natantia group, regardless of size. "Crayfish" or "crawfish" are names given to both a common freshwater crustacean and to the saltwater spiny lobster.

What is the official state marine mammal?

The humpback whale was adopted in 1976 by the Hawaii State Legislature as the official marine mammal of our state. A humpback whale has two lungs—each the size of a Volkswagen, and the throat is only about the size of an orange.

What types of coral reef environments are there?

Hawaii has three types of coral reef environments dominated by: cauliflower coral (*Pocillopora meandrina*) that thrives in strong light and high wave energy, lob coral (*Porites lobata*) that grows in very shallow depths along semiprotected coastlines or in deeper water along exposed coasts; and finger coral (*Porites compressa*) that is found only in protected waters because of its fragile branching growth. There are about 400,000 acres of coral reef in Hawaii.



Did you know that all that yucky stuff on the rocks at the beach is more than what you think it is? Did you know that limu is very important to the marine life cycle and to our fish? Did you know that it can make a hearty meal as well as having other practical uses such as art? Yes, it's true and more!

One of the interesting things about limu, scientifically called algae, is that it can be classified into three different groups—green algae, red algae, and brown algae. The green algae are usually found in shallow waters. This is a very versatile algae and is also the most difficult to classify because it often looks green or brown in color. Tricky limu! Brown limu can also be found in shallow or deep waters. Kelp, a famous brown limu, is made into iodine supplement tablets. Some of the limus are even used in medicine.

Almost all algae found in the ocean are edible. However, most of these algae or limus do not appeal to man's senses such as sight, smell, and touch. Therefore, people often miss out on one of nature's "ono" (delicious), nutritious foods. Many limus are rich in protein, iodine, and vitamins.

Fifty years ago it was a common sight during periods of low tide to see many small groups of Hawaiian tutus in muumuus and hats cleaning limu along sandy beaches. What were they cleaning limu for? Well, in the old days limu was the third component of a nutritionally balanced but monotonous diet consisting of fish and poi. Together they furnished the necessary protein, carbohydrate, and minerals for adequate nutrition. While limu primarily supplied variety and interest, it also added significant amounts of vitamins and other mineral elements to those contained in poi. The famous limus that were traditionally eaten were ogo manaua, limu kohu, and wawae'iole. Here are two excellent recipes to try using limu.

Ogo Kim Chee

(Korean: modified after Korean pickled cabbage)

2 lbs. ogo (limu manaua) chopped into 2 to 3 inch pieces
Handful of coarse Hawaiian salt
2 cloves garlic (chopped) per quart of wilted seaweed
1 to 2 chopped round onions or
1/2 cup chopped green onions
Chili pepper, chopped (to taste) or
1/2 tsp. cayenne (to taste)
1/2 tsp. paprika

Wash and clean the limu. Salt and let stand overnight to wilt. Next day, drain off any liquid and add garlic, onions, chili pepper, and paprika. Pack tightly in jars, seal, and refrigerate. Let stand a few days before using.

Gulamón Salad

(Filipino)

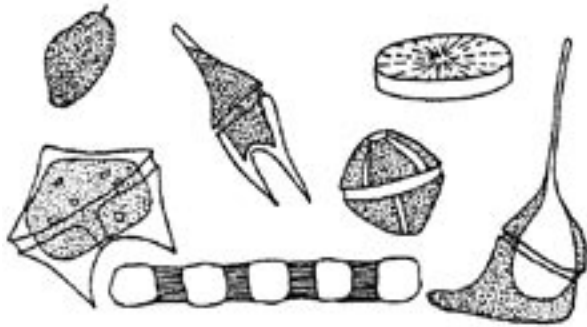
1 lb. or about 3 cups packed limu wawae'iole or limu manaua
3 to 4 cups boiling water
4 large tomatoes
1 tsp. salt
chopped green onions
chopped fresh ginger
2 tbsp. shoyu

Wash and clean seaweed. Pour boiling water over the cleaned seaweed; let stand for a few minutes. Drain well. Chop or mash tomatoes and add to seaweed; add remaining ingredients. Serve cold.

High Seas Drifter

15

What are plankton?



The word **plankton** means drifter. True to its name, plankton are tiny plants and animals that drift in ocean currents. Many of them are so small that you need a magnifying glass or microscope to see them. Plankton can also be larger animals like jellyfish and Portuguese man-of-war that are weak swimmers and cannot swim against the wind or currents.

Scientists divide plankton into two groups—**phytoplankton**, which are tiny plants, and **zooplankton**, which are animals.

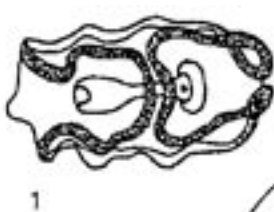
Phytoplankton

Phytoplankton are microscopic marine plants that use sunlight and minerals to grow like land plants. The most familiar sea plant is limu or seaweed, which grow attached to rocks, but phytoplankton spend their whole life floating near the sunlit surface of the ocean. Plankton are the beginning of the marine food web. They are called **primary producers** and provide food mainly for zooplankton.

Zooplankton

Zooplankton are tiny animals that drift in the ocean currents like phytoplankton. Some zooplankton float for their entire life in the ocean. These **permanent zooplankton** do not change their body shapes as adults. Other zooplankton, called temporary zooplankton, spend only part of their lives as adults. These are the eggs and larvae of many kinds of marine animals. As babies, these animals float around. As they grow older, they change their shape and become starfish, sea urchins, crabs, fish, and many other animals.

Can you tell what these eggs and larvae will grow into? Write the number of the larval form of each animal in the boxes below.



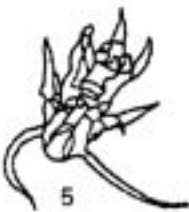
1



2



4



5



3

☐

ulua

☐

crab

☐

sea cucumber

☐

snail

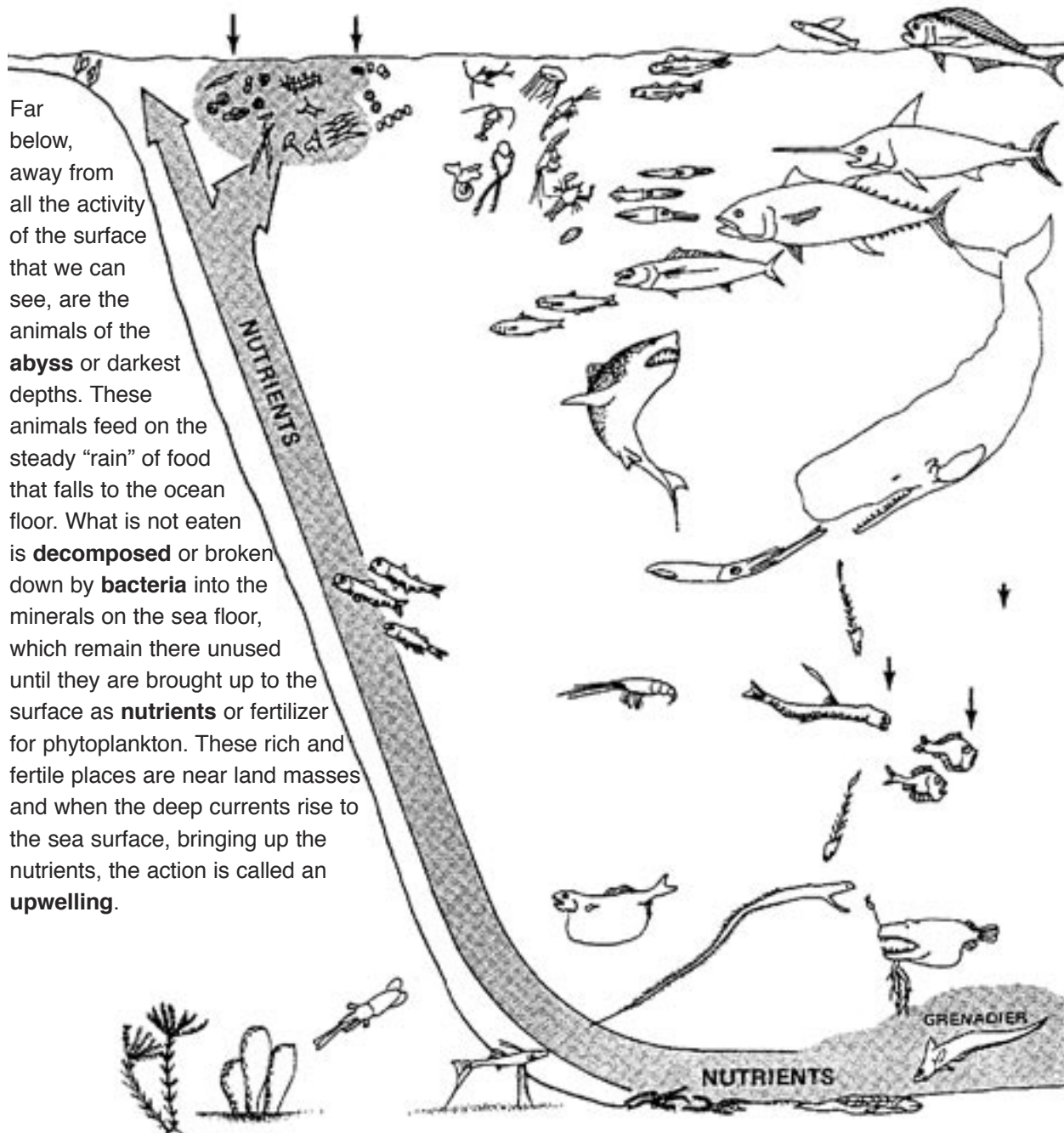
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sea urchin

Marine Food Web

16

All life in the ocean is a part of the **marine food web**. The beginning of the web is in the sunlit zone of the ocean. Here, microscopic phytoplankton use energy from the sun to grow. The phytoplankton then serves as food for other microscopic animals, which in turn become food for larger animals.

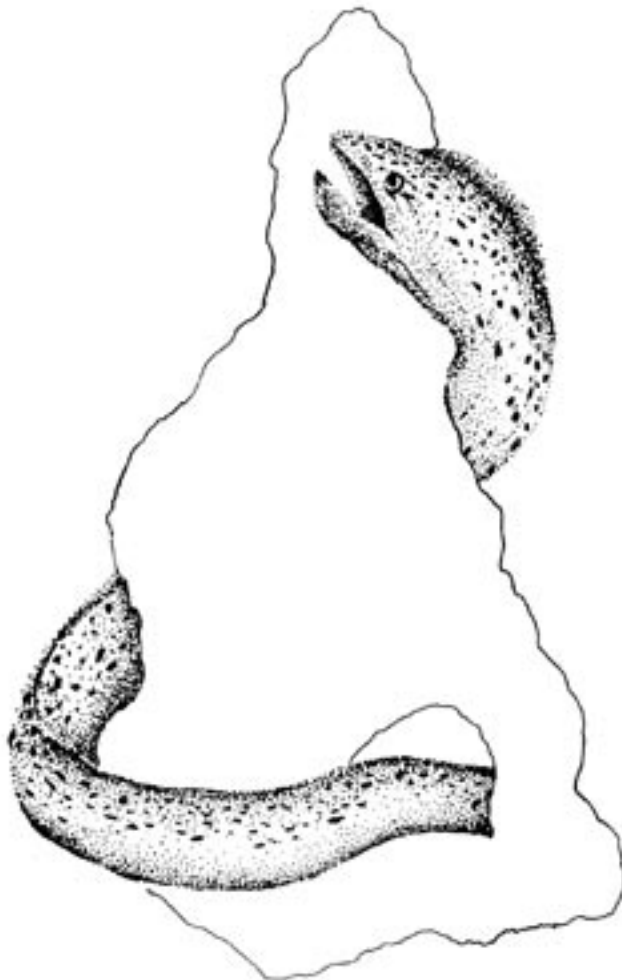


Sea Animals of Hawaii (a word search)

17

A H O L E H O L E H U Y I
H K M O A N A E L A N I H
I X A W E O W E O I I S I
R M E P K I O M H O N O P
L E L C A W A A W A I E O
A H U K L K M F C A N A W
W E K E A I A L A H A K P
A P A I H C A P N E M T A
K I B A K U M U O I O G P
A P M P H K A L I K A L I
W I A U L U L A L A H N O
A P E H O U M U H U M U H
K I H I K I H I N A L A P
N A B E T A R S U L E P O

AHI UHU
AHOLEHOLE UKU
AKU ULUA
AKULE UU
AMAAMA WANA
AWAAWA WEKE
AWEOWEO
EHU
HALALU
HINALEA
HUMUHUMU
KAHALA
KALA
KALIKALI
KAWAKAWA
KIHIKIHI
KUMU
MAHIMAHI
MANINI
MENPACHI
MOANA
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OPELU
OPIHI
PALANI
PAPIO
PIPIPI
PUHI



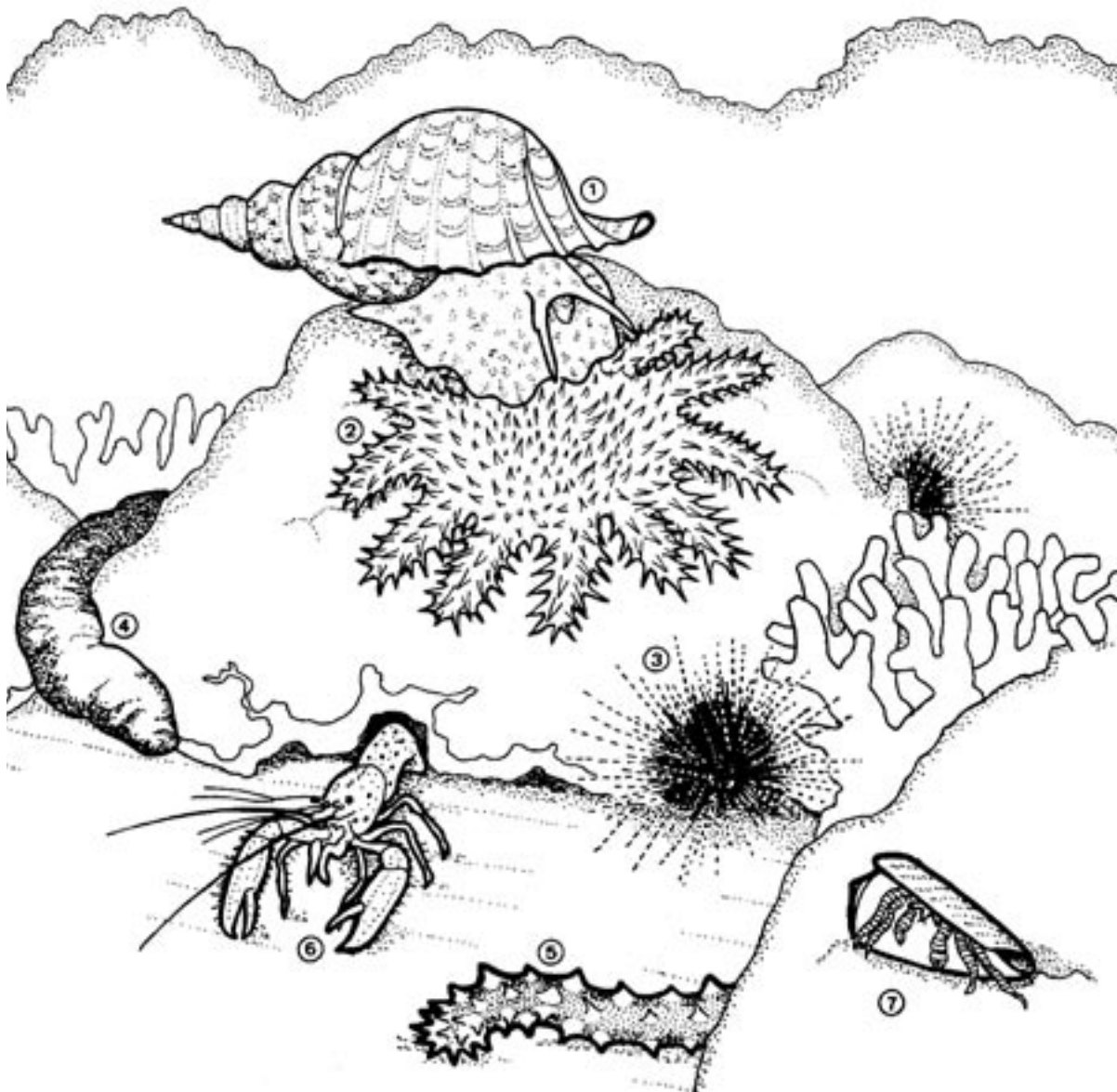
Creepers and Crawlers

18

Most of the reef's creeping and crawling members rest hidden within caves and crevices during the day and come out at night to feed.

The **triton's trumpet snail** (1) is active at night, hunting one of its favorite foods—the crown of thorns starfish. Both the **crown-of-thorns starfish** (2) and all **long-spined sea urchins** (3) have poisonous spines and should not be touched. The crown-of-thorns feeds on coral polyps, while long-spined sea urchins feed on algae.

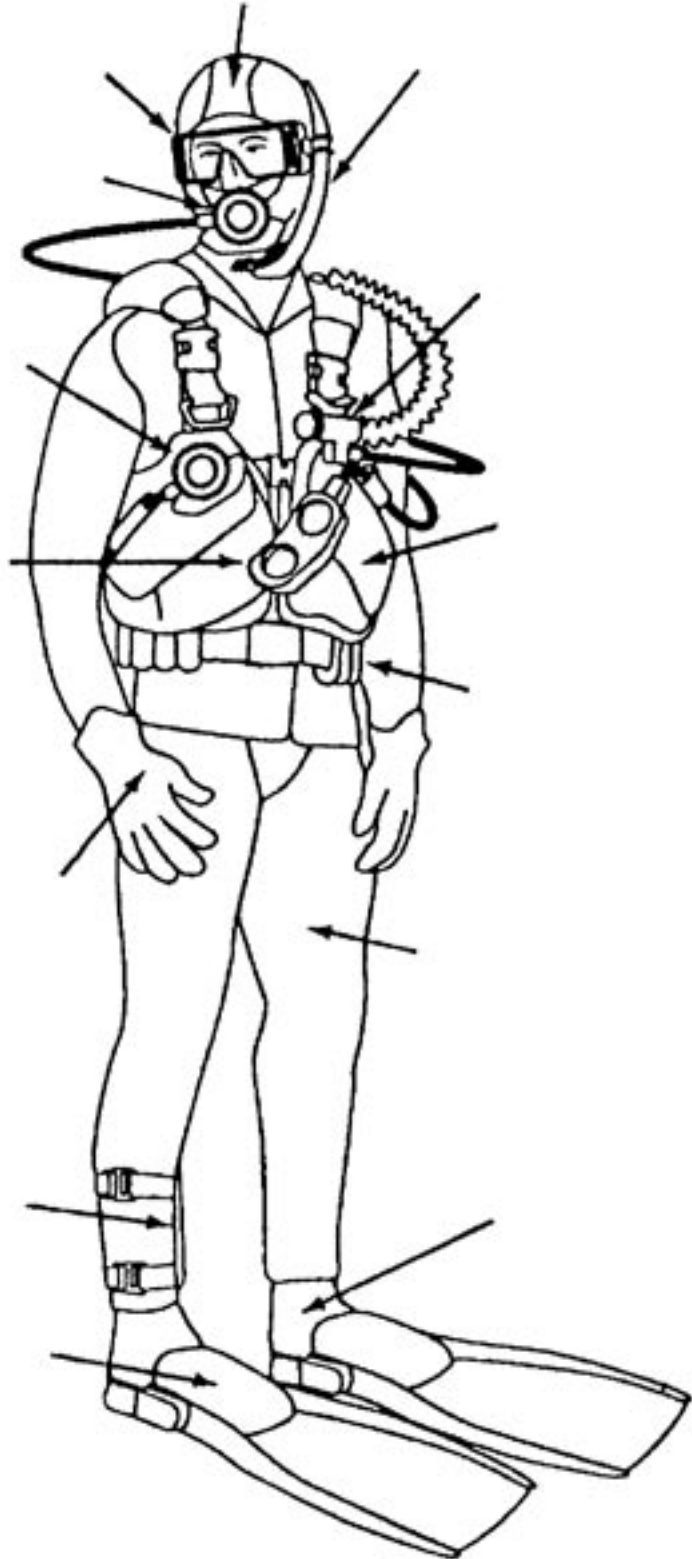
The **black sea cucumber** (4) lives in the open on sandy patches within the reef, sorting through the sand for bits of food. Its cousin the **light-spotted sea cucumber** (5) lives under rocks but stretches its long body out into the open to feed at night. Most **lobsters** (6), along with their relatives the **hermit crabs** (7), shelter by day and are active at night. Hermit crabs live in empty snail shells. As the crabs grow they must find larger empty shells to move into.



SCUBA

19

Diving with Self Contained Underwater Breathing Apparatus (SCUBA) gear is a popular recreation in Hawaii. Can you name the different parts of the gear needed to enjoy this?



Tuna as a World Resource

20

Did you know that the well known tuna, aku, skipjack, is not the only variety of tuna? The family name of tuna is *Thunnus*. The most common tuna in the Pacific ocean are albacore, bigeye, yellowfin, bluefin, and skipjack. The Hawaiian name for the first four species is ahi. Tuna vary in size from 100 cm (aku) to 300 cm (bluefin).

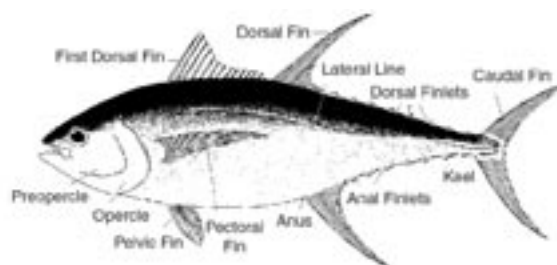
Characteristics of the Different Tunas

Albacore (*Thunnus alalunga*) are found at depths of about 150 meters in abundance in the northern and southern Pacific and Atlantic Ocean, Indian Ocean, and the Mediterranean Sea. They are also found in lesser numbers near the equator. Albacore are caught by long-line and pole and line.

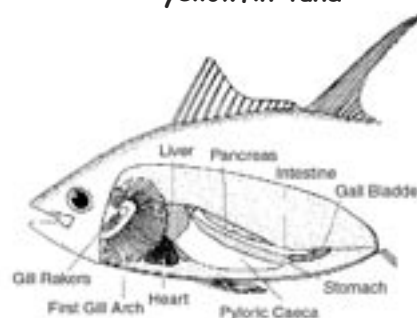
Bigeye (*Thunnus obesus*) are medium-sized fish, about 180 cm in length, and are found in cool temperatures at depths of about 100 meters. They are found in the temperate and tropical regions of the Pacific, Atlantic, and Indian Oceans. Bigeyes are most often found in the currents bordering the sub-tropical counter current and the tropical cold current. Bigeyes are caught by the longline fishery.

Yellowfin (*Thunnus albacares*) weigh nearly 500 kg and are found close to the surface of the ocean. Bluefins are about 300 cm long. They are found in the temperate zones of the Northern Hemisphere to the sub-Arctic in the Pacific and Atlantic Oceans. They are also found in the Mediterranean and Black Seas, and on both the eastern and western waters off Japan. Yellowfin and bluefin are caught by pole and line and purse seine in shallow depths and longline in median depths.

Skipjack (*Katsuwonus pelamis*) is the only one of the five species that is not being fished to the limit of the fishery. They are surface fish. Skipjacks are found in abundance in the Pacific Ocean off Japan and in the Trust Territory, lower California, Mexico, the upper regions of South America, off the coast of Africa in the Atlantic Ocean, and around the Hawaiian Islands. Skipjacks are caught by pole and line in Hawaii and Trust Territory, and purse seine in California.



External anatomy of yellowfin tuna



Handling Procedures

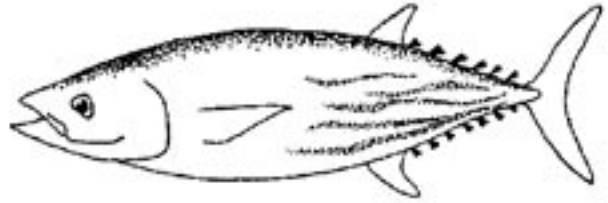
Bring fish on board as fast as you can. Gaff through the lower jaw. Stop the fish from struggling by clubbing. Work quickly and handle the fish gently at all times. Kill the fish with a spike in the brain as soon as it is landed. Bleed the fish immediately after killing. Gut and gill the fish following bleeding. Clean and rinse the fish following gutting and gilling. Start chilling as soon as possible. Chill female and larger fish first. Continue chilling the fish in an ice-seawater mixture while transporting to the wholesaler. Continue chilling the fish as long as it is in your possession. Market only those fish that have been cooled to a core temperature of nearly 0°C (32°F).

—The Management of Yellowfin Tuna in the hand-line Fishing Industry of Hawaii. AR-88-01

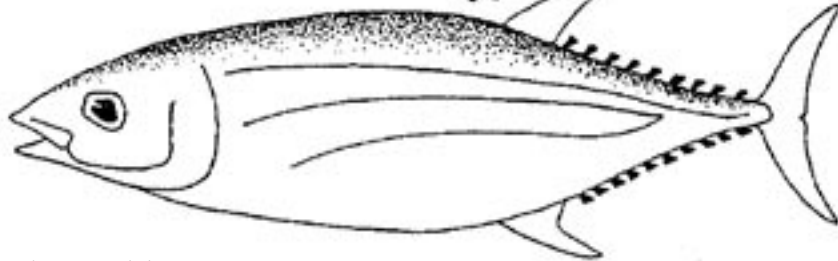
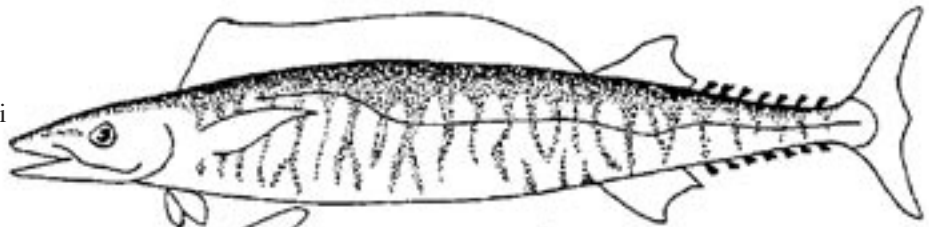
Common Varieties of Tuna

21

Katsuwonus pelamis
SKIPJACK (AKU)



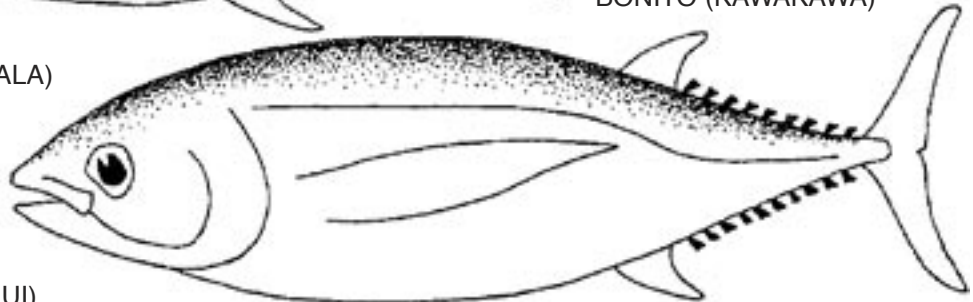
Acanthocybium solandri
WAHOO (ONO)



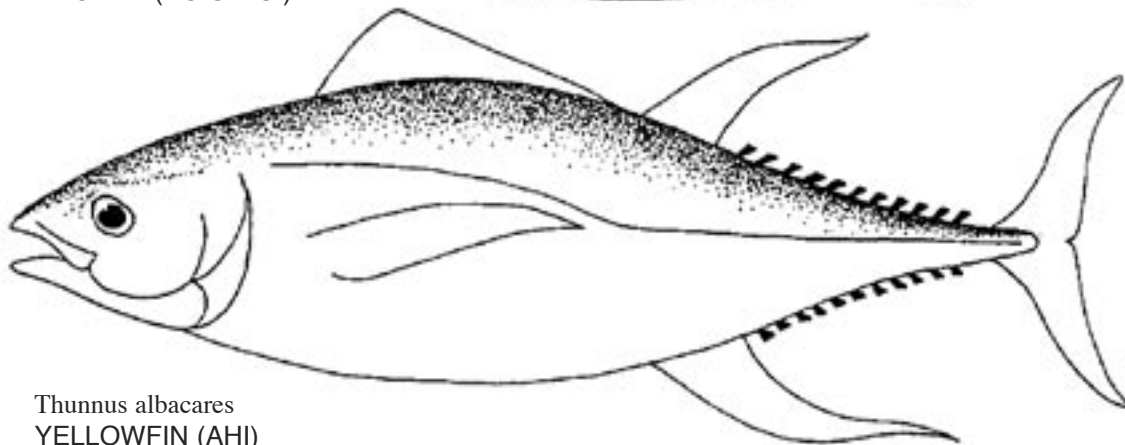
Thunnus alalunga
ALBACORE (AHIPAHALA)



Euthynnus yaito
BONITO (KAWAKAWA)



Thunnus obesus
BIGEYE (PO'O-NUI)

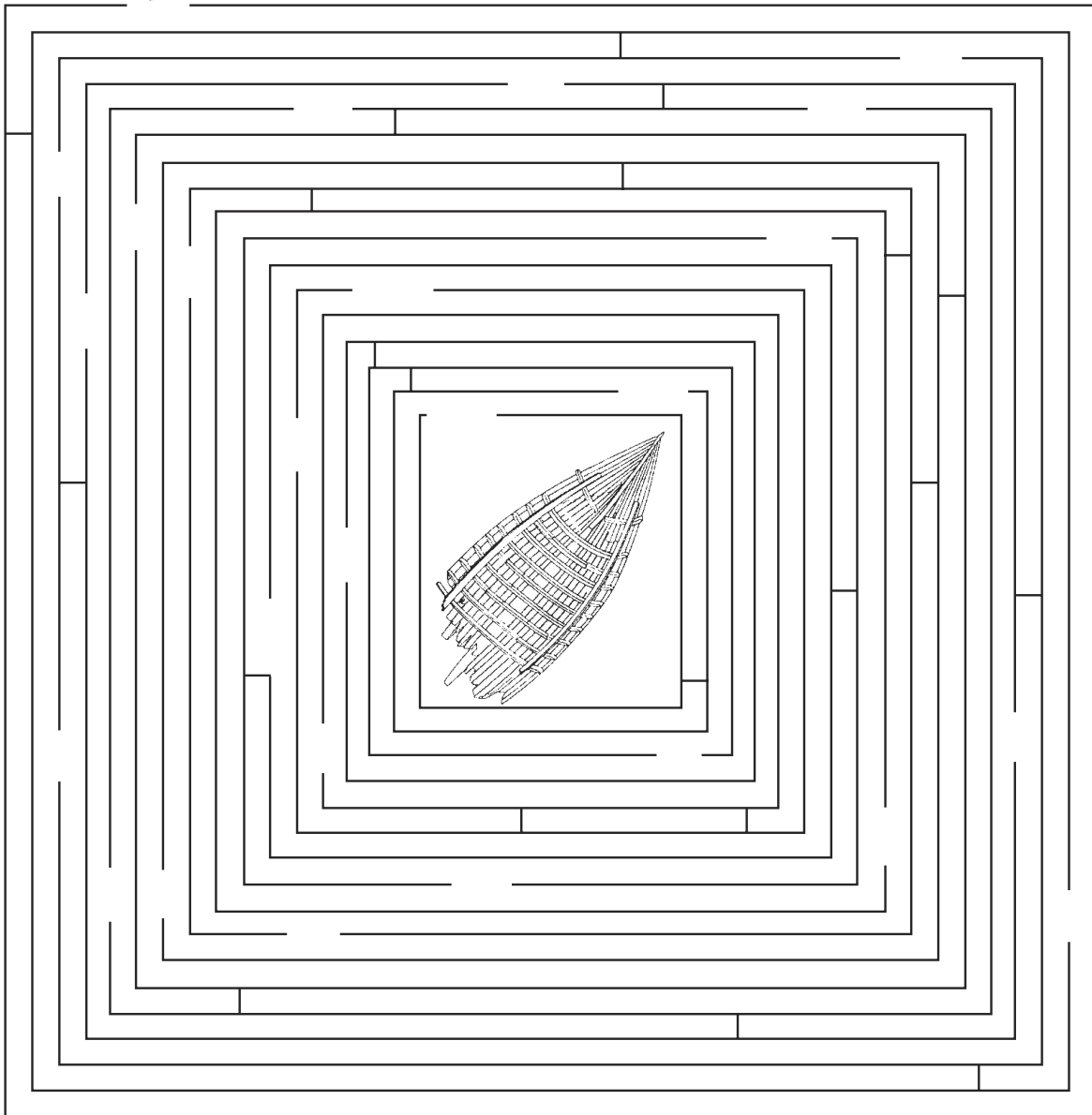
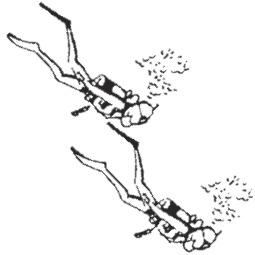


Thunnus albacares
YELLOWFIN (AHI)

Nautical Archaeologists

22

Nautical archaeologists sometimes have to really search for ships. Sometimes there is a maze of seaweed to look through and sometimes its just really dirty water. Here is a maze for you to help the team of divers reach a shipwreck. There are two divers because **safe divers never dive alone**.



What Do You Know About Nautical Archaeology?

23

Here is a little quiz to see how much you know about diving and nautical archaeology.

1. True or false: It's okay to dive alone as long as you don't go really deep and you're a good diver.
2. How old do you have to be to take SCUBA lessons? _____
3. True or false: A diver's knife is used for fishing and for killing sharks, or any other threatening fish.
4. What is context, and why isn't it okay to take souvenirs home from a historical site?

5. To whom do shipwrecks and other historical sites belong?

6. What good are broken bits of pottery and other "trash?"

7. True or false: Artifacts should always be taken care of and conserved. They should never be brought to the surface just to dry out and shrink.
8. What are "concretions" and why are they a problem to nautical archaeologists?

Gyotaku (Japanese Fish Printing)

24

The technique of Japanese fish painting has been used in Japan for over 100 years to record catches of sports fish and to gain ichthyological (fish biology) information. These prints have been used at the University of Washington to study how the physiology of a fish is related to its surface area.

The art of gyotaku (pronounced ghio-ta-koo) is a good way to gain an understanding and appreciation of the beauty and great variety of marine organisms. You can also use this technique for making prints of shells, rocks, flowers, and other items.

Before you make a print, identify the fish. What are the distinguishing characteristics of the fish? Study the life history of the fish. Where and how was it caught?

Materials

Obtain a very fresh fish. If you buy the fish at a market, select one that has bright red gills, clear eyes, and a fresh smell. If the fish has been gutted, make sure that it has not been cut anywhere else on the body.

You also need:

- newspaper
- plastic molding clay
- pins
- water based ink (linoleum block ink is best)
- a stiff 1/2-inch brush
- a very small brush
- rice paper, newsprint, or other moisture tolerant paper (because rice paper is expensive, you might prefer to start with newsprint)



Method

1. Use soap and water to clean the outside of the fish as completely as possible. The cleaner the fish, the better the print. Dry the fish well.
2. Place the fish on a table covered with newspapers. Spread the fins out over some clay and pin them in this position. Continue to dry the fish.
3. Brush on a thin, even coat of ink. Leave the eye blank unless you prefer to fill it in.
4. Place a piece of newsprint or rice paper over the top of the fish.
5. Carefully lay the paper over the entire fish. Use your fingers to gently press the paper over the surface area of the fish. Be careful not to move the paper too much because this results in double prints. Then remove the paper and you have a fish print.
6. Use a small brush to paint the eye.

Cheat Sheet

25

Page 1

1. New Zealand
2. Cook
3. Friendly
4. Tahiti
5. Christmas
6. Kauai
7. New Albion
8. Vancouver
9. Cook Inlet
10. Bering
11. Alaska
12. Arctic Ice
13. Siberia
14. Hawaii

Page 2

- | | |
|-----------------|---|
| Before 100 A.D. | H |
| 1778 | A |
| 1820 | E |
| 1840 | D |
| 1878 | F |
| 1925 | B |
| 1946 | C |
| 1976 | G |

Page 9

1. c
2. d
3. b
4. a

Page 15

- 4 ulua
- 2 crab
- 1 sea cucumber
- 3 snail
- 5 sea urchin

Page 6

- | | |
|-------------------------|---|
| Put litter in its place | B |
| Catch only what | B |
| Do not collect | B |
| Follow posted signs | B |
| Do not spear | B |
| Replace overturned | B |

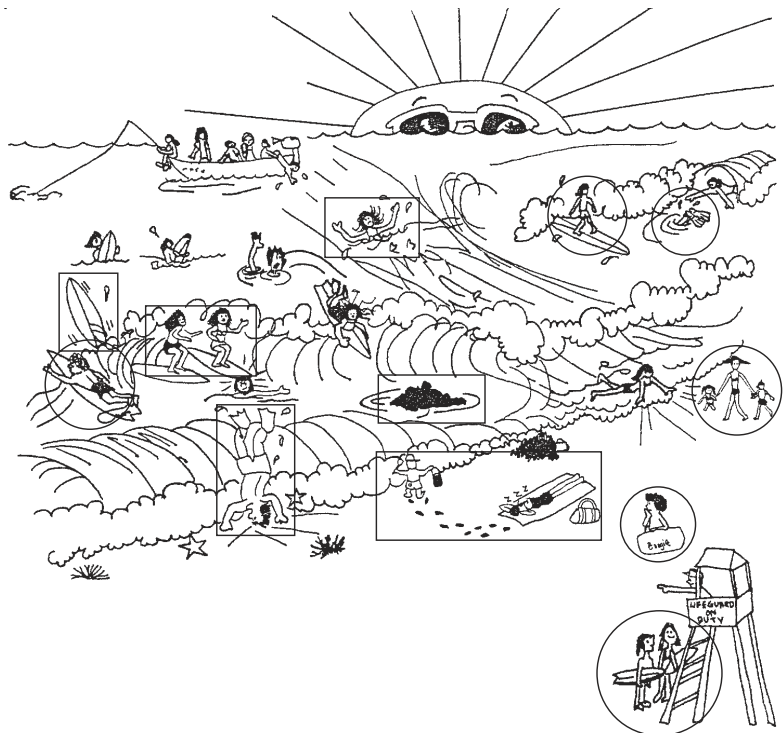
Page 3

Safe things to do (circles)

- asking lifeguards about the water
- wearing a surfboard leash
- supervising children
- diving under a breaking wave
- surfing ahead of the curl, not straight into shore
- staying out of the water if the waves look too big for you

Dangerous things (squares)

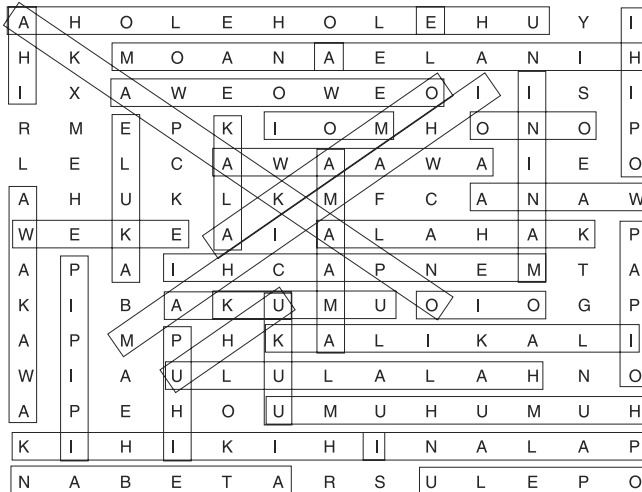
- unsupervised child
- swimmer caught in rip
- loose surfboard
- going "over the falls"
- crowded wave
- rocks



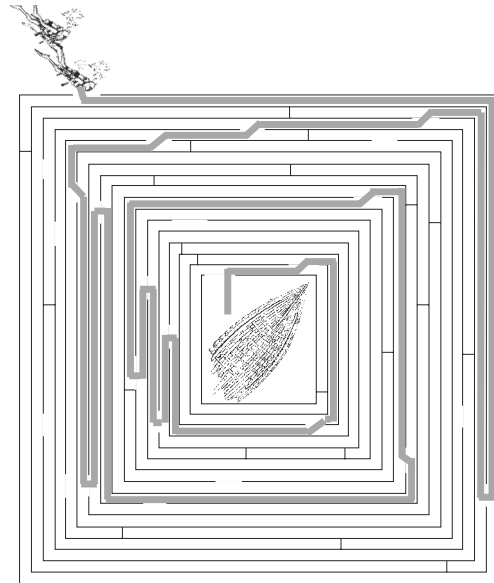
Cheat Sheet

26

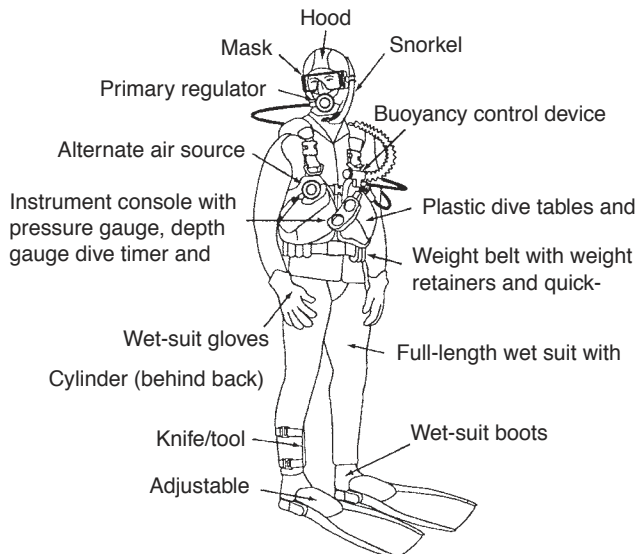
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1. False. It is unsafe to dive alone, since even the best equipment can fail.
2. PADI requires at least the age of 12.
3. False. A diving knife is only to be used as a tool. It is designed to free a diver from entanglement, or to dig. Underwater fishing is dangerous as any amount of blood in the water attracts predators.
4. Context is the relationship you find an artifact in. Context helps the archaeologist have a better understanding of the artifact and to whom it belonged.
5. Shipwrecks and historical sites belong to everyone, they are a part of our collective past. That is why we must all take an interest in preserving and protecting them.
6. Every small bit of information can give us clues about a site. Even broken bits and trash can tell us what they were using, how much, why this trash and not others.
7. True. If the artifacts cannot be taken care of, they are probably better off where they are. If they have survived this long, they can survive a little more until you are able to protect them.
8. Concretions are the shells and dead parts of little marine creatures. Over time they build up on metals and other artifacts underwater.

