# MAKAHIKI KAI
## festival of the sea

## STUDENT WORKBOOK

UNIHI-SEAGRANT-MR-80-01
July 1979

University of Hawaii
Sea Grant College Program

**MAKAHIKI KAI**--the Festival of the Sea--is a marine exhibit which brings together the ocean environment and its resources and human interaction and use of the ocean itself and its products. The first exhibit was held in 1974 and each year until 1978, large displays were created which focused on a different aspect of the ocean from the changing face of the Hawaiian coastal plains to the ecology of the ocean at different depths and the influence of human society in the exploitation of marine resources for recreation, industry, habitat, food, and esthetics.

This workbook is a composite of those which were developed to provide students who participated in Makahiki Kai with post-visit activities in the classroom. Four editions of "Teachers' Guides" were also published.

Support for the exhibits has come from the State Legislature through direct grants, the Office of the Marine Affairs Coordinator, certain trust funds administered by the Hawaiian Trust Charitable Foundation and McInerny Foundation, the Sea Grant College Program, and in-kind support from state agencies such as the Department of Land and Natural Resources, Anuenue Fisheries Research Center, Department of Planning and Economic Development, and the Department of Education, and the faculty and staff of the University of Hawaii, especially those affiliated with the Hawaii Institute of Marine Biology.

# TABLE OF CONTENTS

# HAWAIIAN TIDAL POOLS

Have you walked along a rocky coast and noticed a tidal pool? What do you see when you casually glance over those areas of water trapped by rocks and land? You may see limu-covered rocks, a fish darting quickly for cover, a crab sunning but warily watching you.

If you peer more closely, you will view an exciting realm of marine life that you would have missed with a casual glance.

Blennies, the agile rockskippers, jumping from pool to pool to escape their enemies;

Young damselfishes chasing other tiny fishes away from their territories;

Hermit crabs examining a new shell as a possible home;

Long spined sea urchins (wana) waving their spines in response to a fish passing by (they are protected by their long poisonous spines so please do not touch);

Opihi crawling about on wet rocks feeding on algae;

Small cone shells which employ poisonous darts to paralyze their prey before eating them;

Various shrimps such as the colorful red and white bandana prawn, crawling about in crevices.

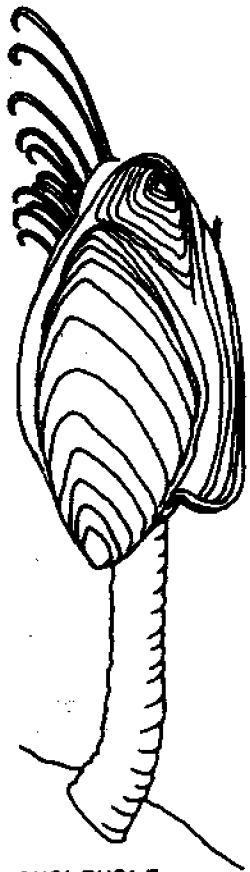
If you look at the tidepools themselves you will find that they are of two types, those created by periodic wave splashes (splash pools) and those formed by retreating tides (intertidal pools).

Splash pools are situated high on rocky benches and the animals living within them must tolerate wide variations in temperature and salinity. The blenny, opihi, and nerite (pipipi) are a few animals commonly found in splash pools.

Intertidal pools disappear at high tide and are reformed at low tide. Animals living within this type of pool are able to withstand strong wave surge.

Intertidal pools are an important link in the life cycles of many marine animals. They are inaccessible to large predatory animals and serve as nurseries for fishes that later grow to larger sizes in the sea. They teem with miniature marine life, and provide permanent homes for many smaller animals which seek protection from larger animals in deeper water.

The lives of all of us in Hawaii are intrinsically touched by the ocean and for those who like to explore, look for a fascinating tidal pool and you will come to cherish these easily accessible windows to the sea.



# SEASHORE LIFE

## -- a word search

(Answers on page 31)

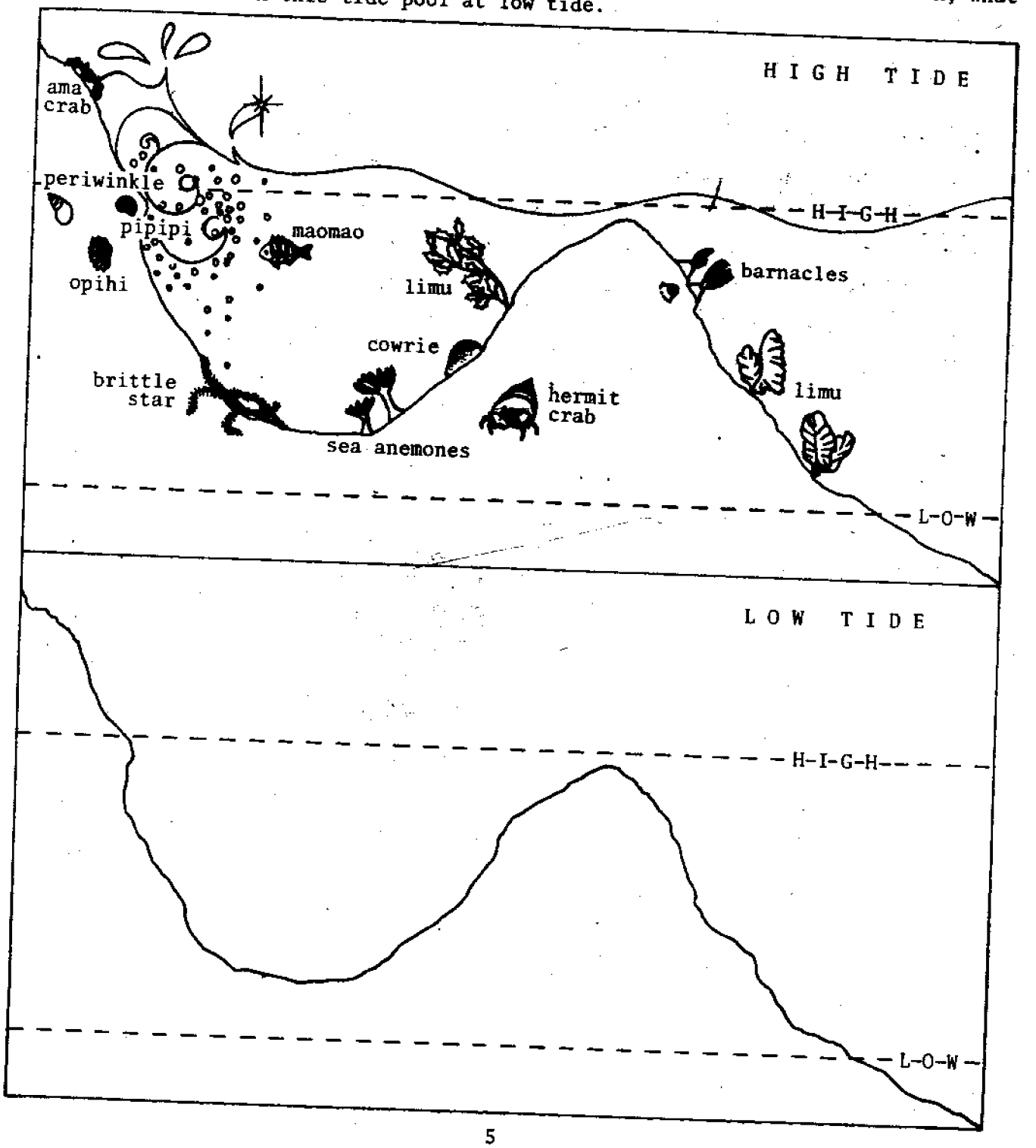
H S I F L E R R I U Q S T Q L M R T A M S
S M A B A R C D N A S P K U P I P I C L A
I A E B R I T T L E S T A R F I S H B G R
F E L L U F A M A O A A I P I P I P M I F
N T A E Y K A C S N L I M U R E L O Q J H
O P N N O M U X A U H I H E E T V U C D M
E R I N O C O W R I E B E L O H E L O H A
G T H Y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

AHOLEHOLE, SILVERPERCH
ALAIHI, SQUIRRELFISH
BANDANA PRAWN
BARNACLE
BLACK ROCK CRAB
BRITTLE STARFISH
CONE SHELL
CORAL
COWRIE
CRAB
EELS
FLOUNDER
GOBY
HE'E, OCTOPUS, TAKO
HERMIT CRAB
HINALEA, WRASSE
KUPIPI
LIMU, OGO, BROWN, GREEN, RED
LIZARDFISH
LOLI, SEA CUCUMBER
MAMO, MAOMAO
MANINI
MULLET
NEHU
NUDIBRANCH
OAMA, WEKE, GOATFISH
OIO, BONEFISH
OPIHI
OYSTERS
PALANI, SURGEONFISH
PIPIPI
ROCK SKIPPERS, BLENNY
SAND CRAB
SAND TURTLE
SEA ANEMONE
SHRIMP
TURTLE EGGS
ULA, LOBSTER
WANA, SEA URCHIN
WORMS

# UPS AND DOWNS OF TIDE POOL LIFE

Below is a diagram of a tide pool during HIGH TIDE. The tidal pool animals are busy eating, moving about and enjoying the cool, fresh sea water that is bringing in food and oxygen into the pool.

At LOW TIDE the tidal pool zone looks like a different place. Draw in, what it would be like in this tide pool at low tide.



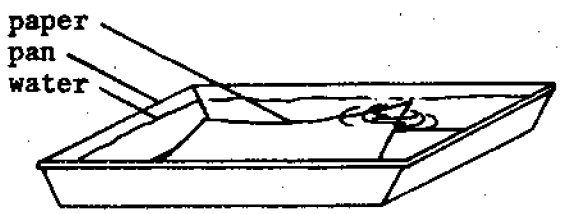
# ALGAE PRESS

Seaweeds are the plants of the sea. In Hawaiian, they're called limu; scientists call it algae ("al-gee"). There are three major kinds of algae: reds, greens, and browns.

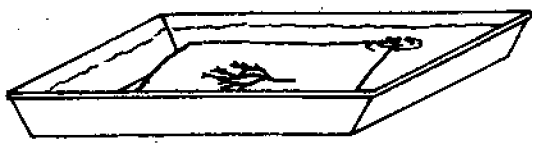
In studying the different kinds of algae, the best method to preserve them is by pressing, much like you would the leaves of land plants. Once the algae is pressed and dried, it can be saved for future reference. Botanists, the scientists who study plants, press seaweed in an algae press. We can make our own press using much simpler materials.

## AN ALGAE PRESS

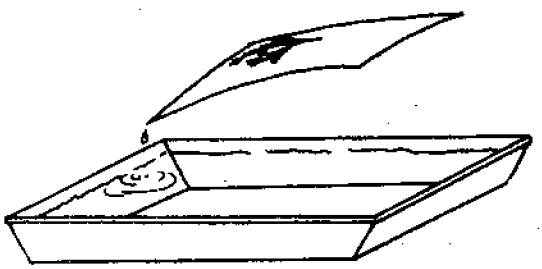
MATERIALS NEEDED:
- old magazines, newspapers
- smooth drawing or botany paper
- waxed paper
- scissors
- heavy weights: large books, bricks, stones, etc.
- a flat, shallow pan
- water
- seaweed



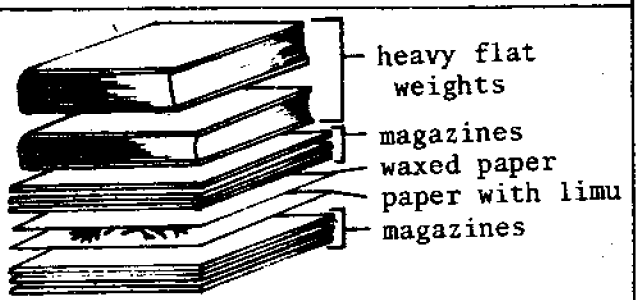

STEP 1: Fill the pan with about 1" of water. Cut a piece of drawing paper small enough to fit into the pan and lay flat on the bottom.



STEP 2: With the piece of paper lying on the bottom of the pan, float a piece of algae in the water to position it on the paper.



STEP 3: Carefully lift the paper, algae and all, out of the water.




STEP 4: In your "algae press" layer your materials as shown.

With some planning ahead, a booklet of different types of algae can be compiled. When the seaweed has been identified, this will be what botanists call an "herbarium" ("erb-a'-ree-um"). (If you are an artist at heart, these seaweed pressings can be made into greeting cards, wall hangings, collages, etc.!)

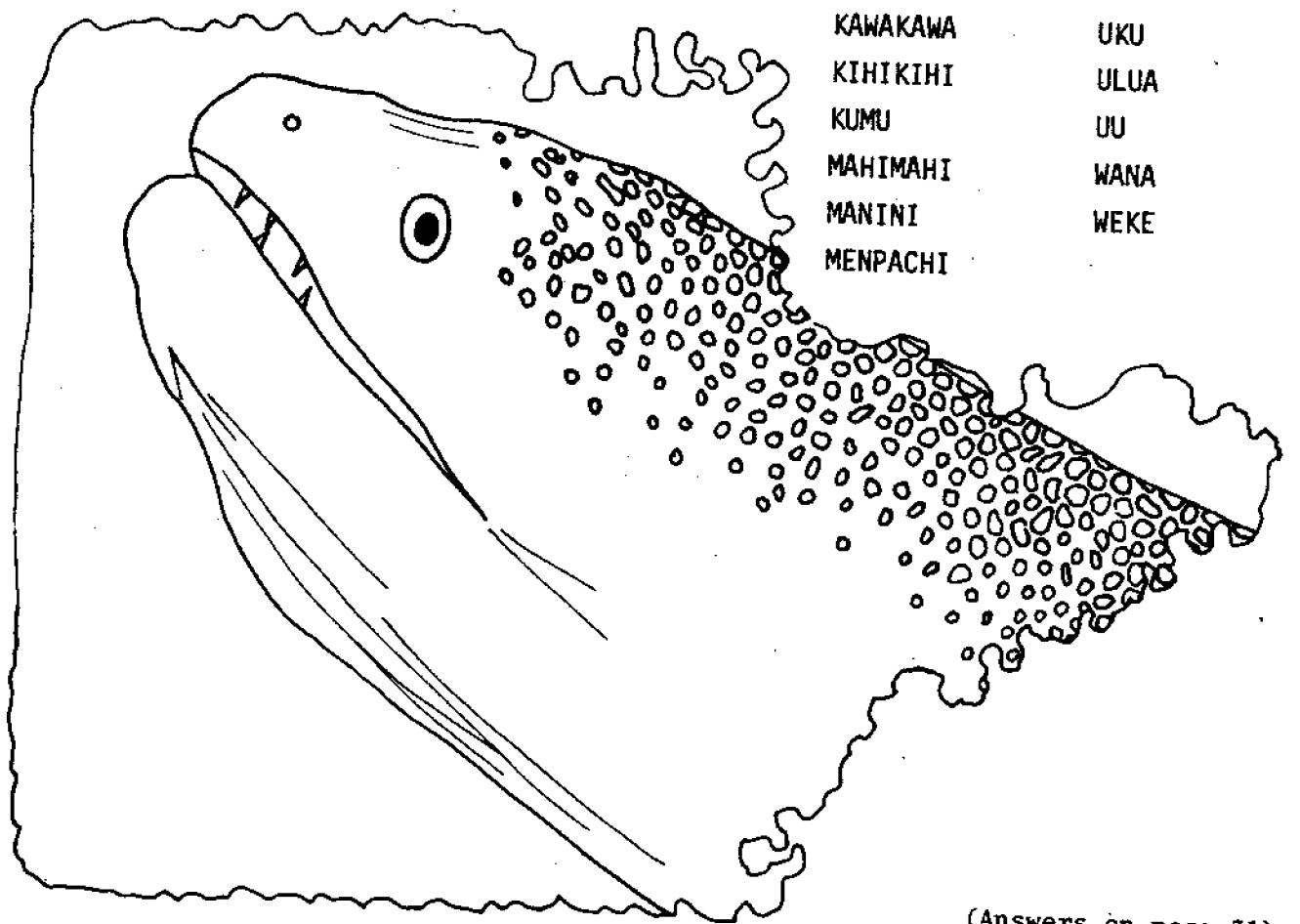
## A FINAL NOTE ON COLLECTING ALGAE

Algae is commonly found along the seashore in shallow waters. If you have ever gone to pick "ogo" to eat, you know where to look. Don't forget that seaweed also likes to grow around old pilings around the harbor, on old lines that have been hanging from the dock for a long time. Take along a zip-loc bag--it's handy for collecting specimens with a little bit of water.

# MARINE ANIMALS OF HAWAII -- a word search

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



(Answers on page 31)

# SKELETONS
## -- in our "sea closet"

Match skeletons to the animals:

Slate-pencil sea urchin
*('ina'ula)*

Partridge tun shell

Sand dollar

Spiked prawn
*('opae kakala)*

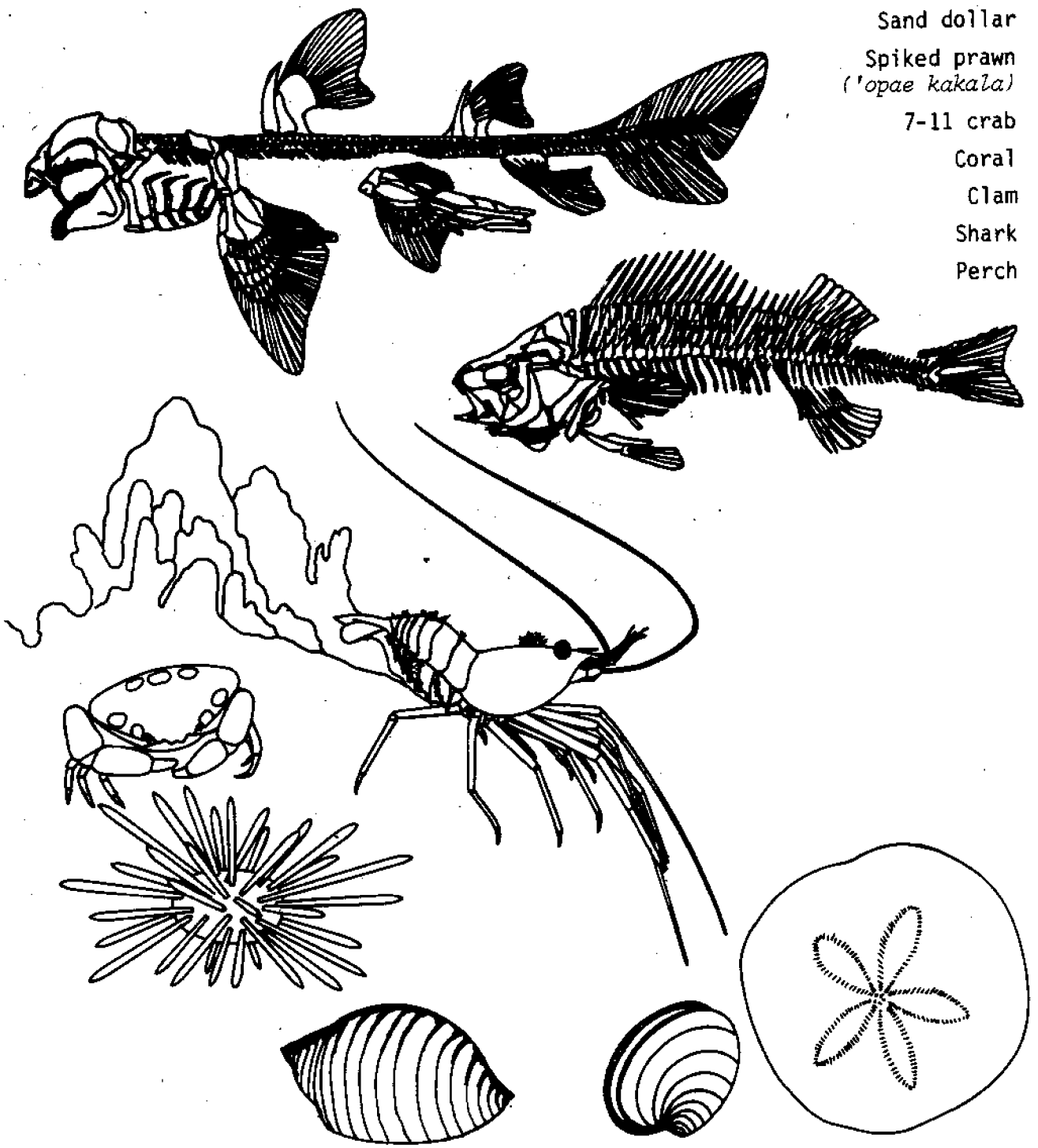
7-11 crab

Coral

Clam

Shark

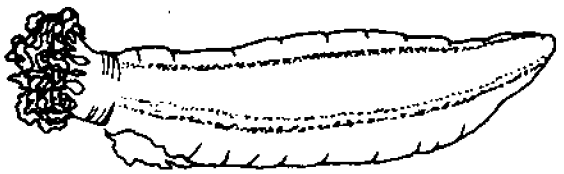
Perch



# REEF VERTEBRATES AND INVERTEBRATES

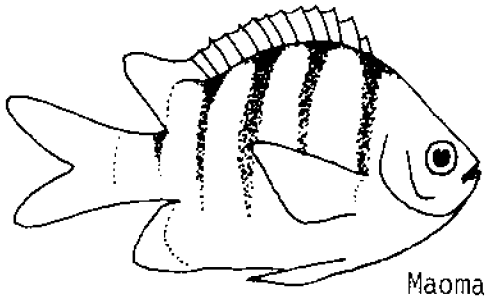
Most animals can be divided into two broad groups--the vertebrates and invertebrates. VERTEBRATES are animals with backbones. Some of these animals have a spinal column while other more primitive vertebrates have notochords to support their bodies. INVERTEBRATES are animals without a backbone or skeleton inside their bodies. Some invertebrates "wear their skeletons on the outside of their bodies." Their bodies are supported by hard outer shells.

In the blank below each animal, write whether you think the animal is a vertebrate or invertebrate. (Answers on page 31)



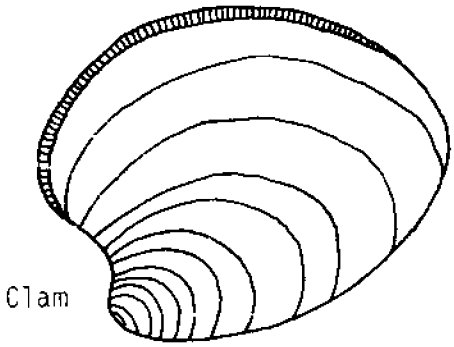
Sea cucumber

1 _____



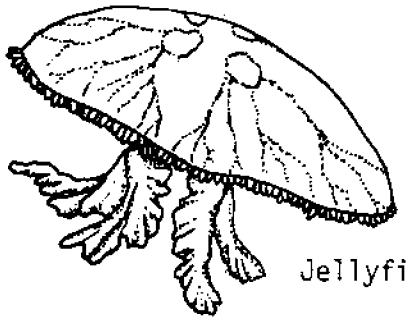
Maomao

2 _____



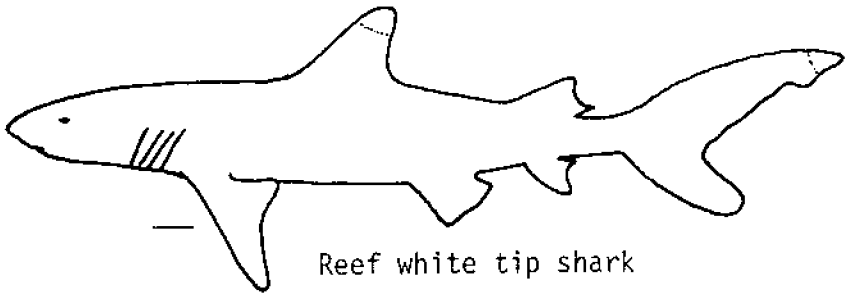
Clam

3 _____



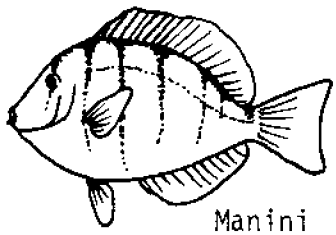
Jellyfish

4 _____



Reef white tip shark

5 _____



Manini

6 _____

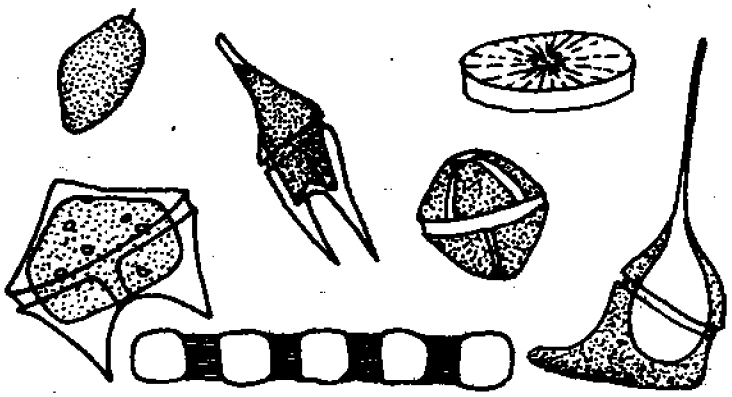
# HIGH SEAS DRIFTER

## 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 the 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



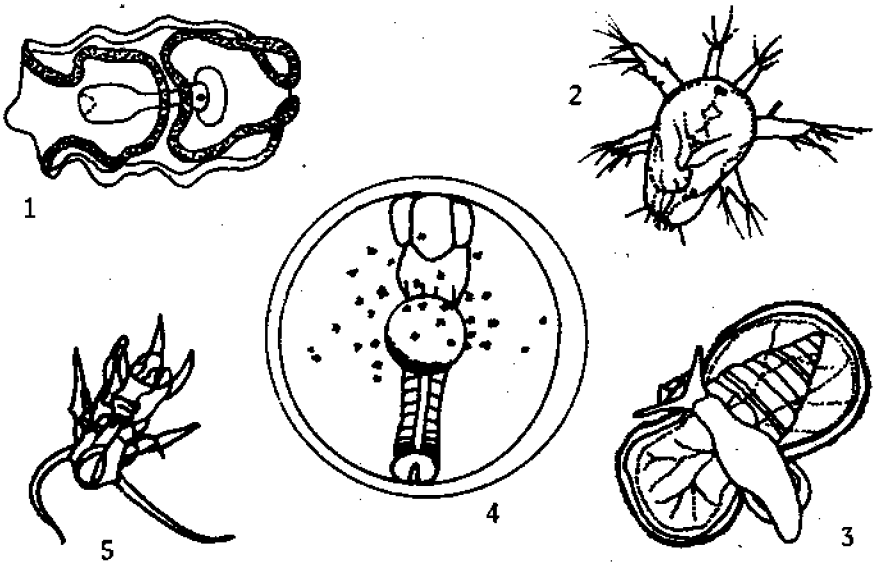
Phytoplankton are microscopic marine plants that use sunlight and minerals to grow like land plants. The most familiar sea plant is limu or seaweed, which grow attached to rocks, but phytoplankton spend their whole life floating near the sunlit surface of the ocean.

Plankton is 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 but 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 in the boxes below of the larval form of each animal.

☐ ulua

☐ crab

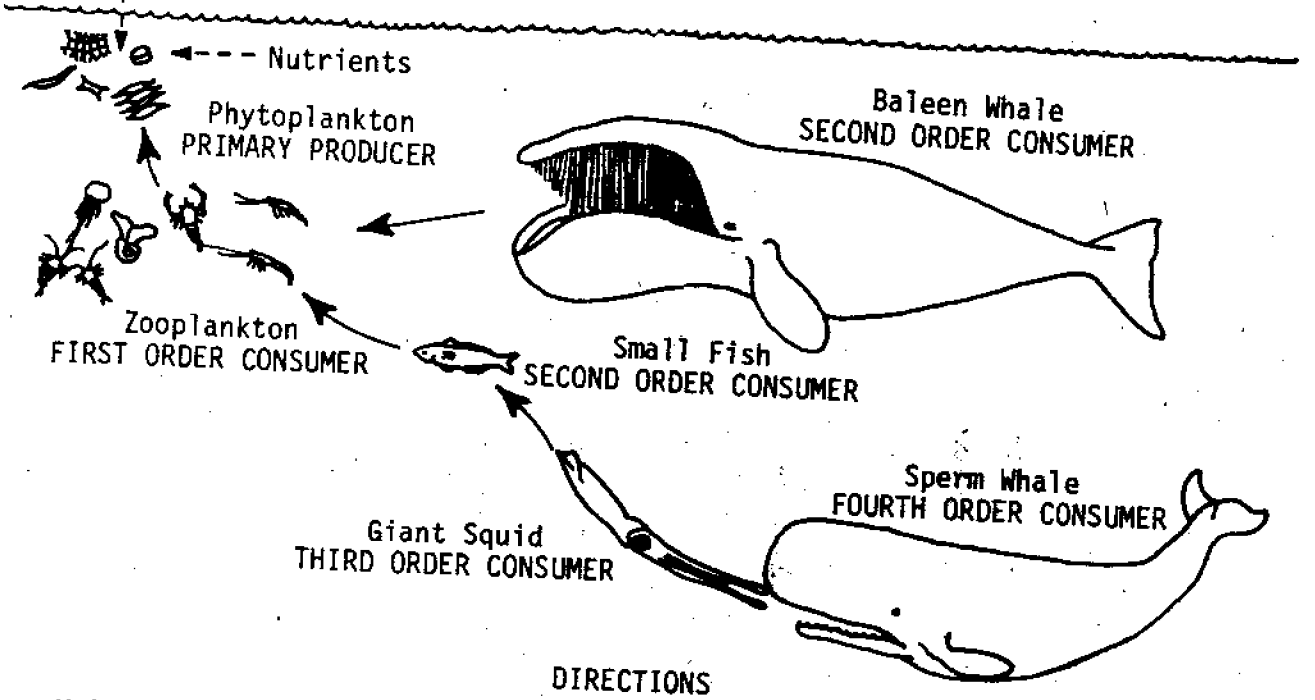
☐ sea cucumber

☐ snail

☐ sea urchin

(Answers on page 31)

# FOOD WEB




DIRECTIONS

Using the diagram of the FOOD WEB, complete the following sentences by filling in the blanks. (Answers on page 31)

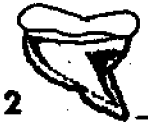
The two food chains start with (1) _____ or tiny plants. The phytoplankton are called (2) _____. It is the first link in most food chains. All phytoplankton need to grow are (3) _____ and (4) _____.

(5) _____ eat phytoplankton. Zooplankton are (6) _____. The (7) _____ and (8) _____ are SECOND ORDER CONSUMERS. Squid are (9) _____ ORDER CONSUMERS. If a sperm whale eats the squid, it becomes a (10) _____ ORDER CONSUMER. What order consumer would you be if you ate the squid? (11) _____ ORDER CONSUMER.

These animals are not the only animals in the ocean. When you include all the animals and what they eat, this is called a FOOD WEB.

# SHARKS TEETH MATCHING

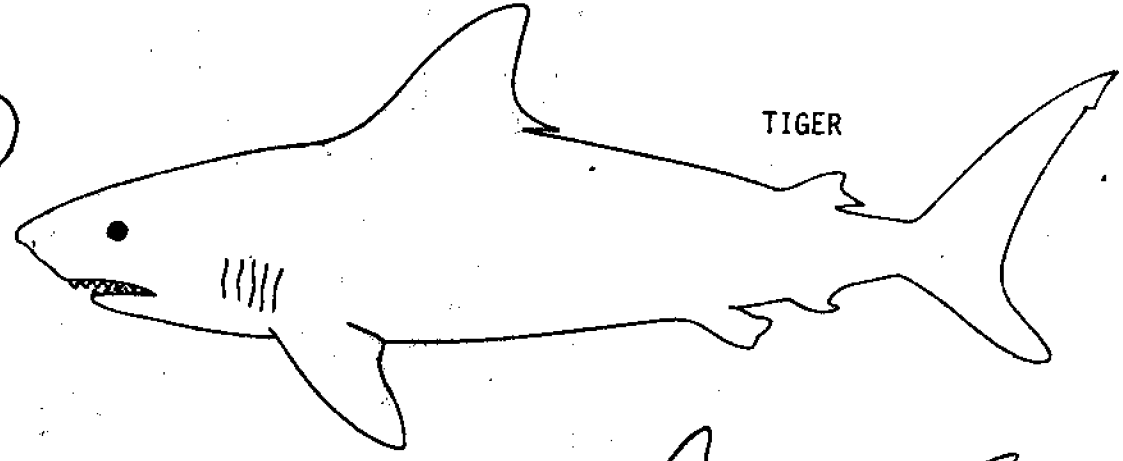
1 _____



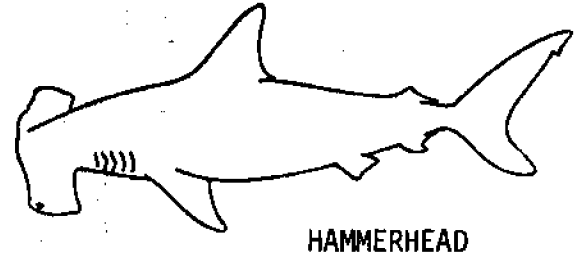
2 _____

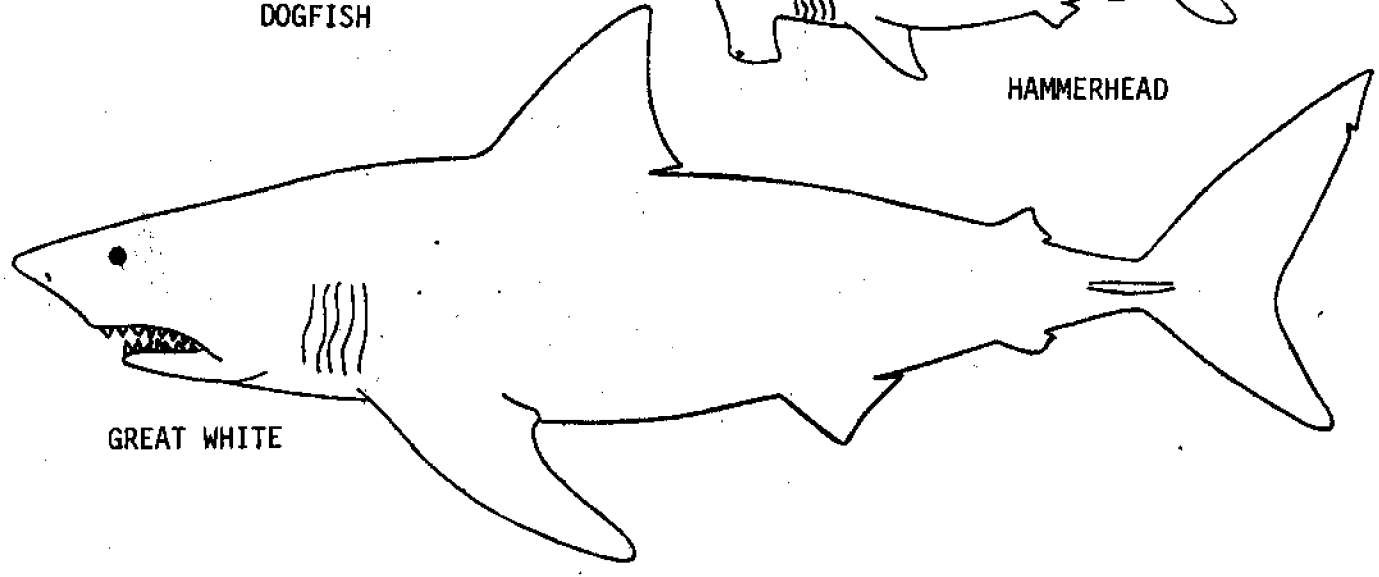
3 _____

4 _____







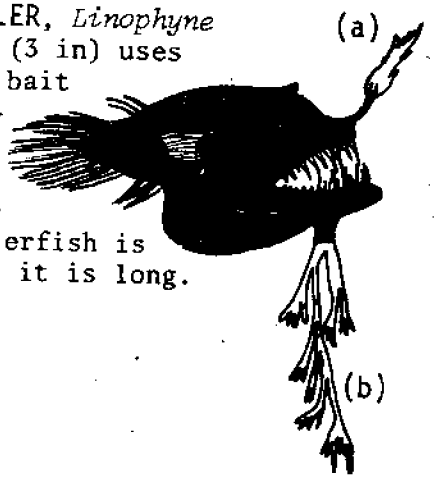

(Answers on page 31)

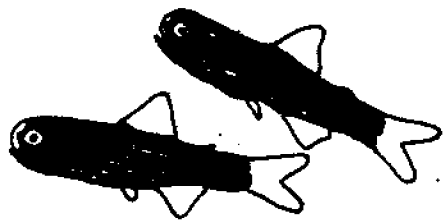
# DARKEST DEPTHS

Only animals that are best suited to the place in which they live survive. The animals of the great depths, or abyss, have to be able to live in a place where no surface animal, including man, can live. The abyss is so far below the ocean's surface that it is out of reach of the sun's light and warming rays.

This makes the abyss always pitch black and very cold, just above freezing. Another thing abyssal animals must adapt to is the great pressure from the weight of the water above. Mainly because of these three reasons, food is very scarce. To survive, the animals have adapted themselves so they can eat what comes along and they can also produce light to attract prey.

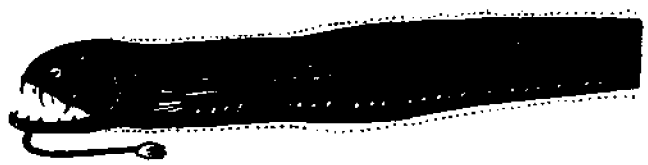
The DEEP-SEA ANGLER, *Linophyne arborifera*, 7 cm (3 in) uses its (a) luminous bait and (b) chin barbel to attract food to it. Unlike most abyssal fish the anglerfish is almost as wide as it is long.



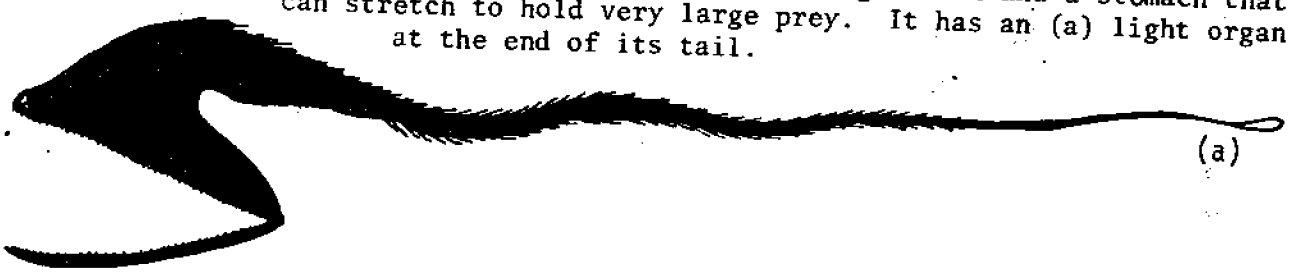



LANTERN FISH, *Diaphus macrophus*, 4 cm (1.6 in) comes up to the surface at night to feed.

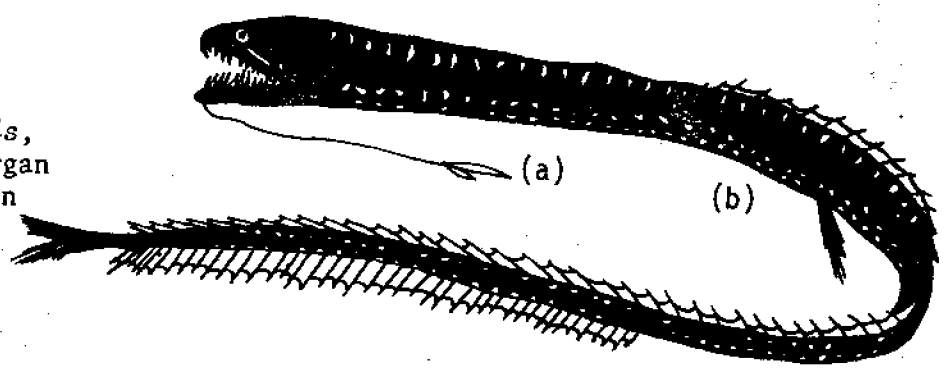
*Stomias affinis* also has a luminous chin barbel and is 9 cm (3.5 in) long.



GULPER EEL, *Eurpharynx pelacanoides* (60 cm), has a huge mouth and a stomach that can stretch to hold very large prey. It has an (a) light organ at the end of its tail.




This STOMIATOID FISH, *Idiacanthus panamensis*, has (a) a luminous organ at the end of its chin barbel and bluish-white patches, and (b) light organs that line its 15.2 cm (6 in) long body.



# HAWAIIAN GEOLOGY

The Hawaiian islands are almost completely volcanic.

Quiet eruptions of lava on the sea floor gradually built up broad turtle backed mountains called SHIELD VOLCANOES. As the mountain top neared the surface, explosions occurred, but as it built above the sea level quiet eruptions resumed. Later, the top of the volcanoes sank to form craters called CALDERAS. Over long periods of time eruptions continued and filled the calderas.

Further on in the volcanoes' history, eruptions became more explosive and a steep sided bumpy cap was formed on top of the shield.

As these eruptions died out erosion took great bites out of the volcanic mountains and jagged mountain ranges were formed. The gravel, sand, and clay formed by the weather and erosion were washed down, some into the ocean and some deposited on the floor of the valleys and into the shallow water around the island. At the same time corals and algae started to build fringing reefs around the islands.

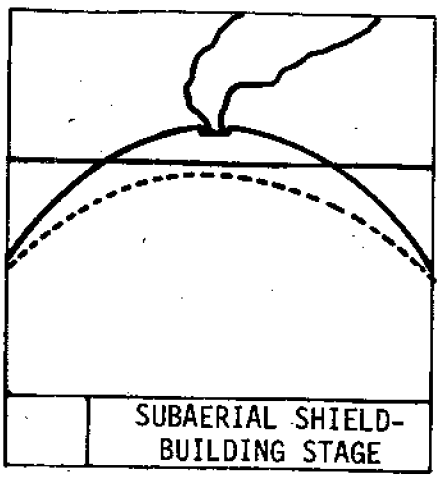
During the glacial period, the sea level repeatedly rose and fell because the changes in temperature caused ice on the continents to melt and re-freeze. Hawaii was greatly affected and at different times sea level was as much as 91 m lower and at other times 76 m higher than it is now. When the sea level was 7.6 m above the present level a broad coral reef was built along the south side of Oahu, forming the present Honolulu and Ewa plains. Later during lower sea level, streams cut valleys into the reef and when the sea level rose again the mouth of the valleys were flooded. Pearl Harbor is an example of such a geological formation.

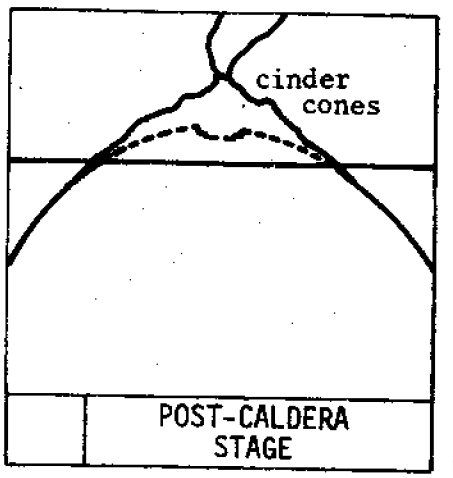
## GLOSSARY

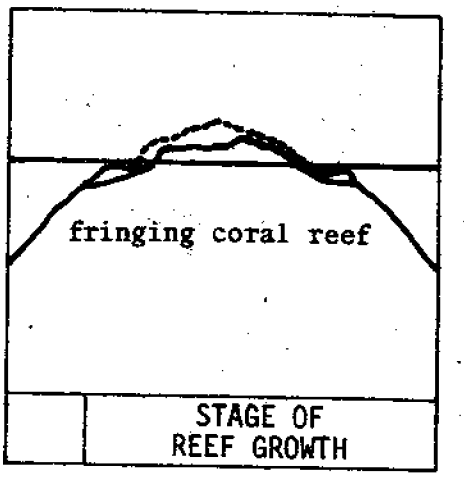
| | |
|---|---|
| Ash cones | Tip of volcano consisting of particles of mineral matter |
| Atoll | Coral island consisting of a reef surrounding a lagoon |
| Caldera | Large crater formed by collapse of central part of volcano |
| Cinder cones | Tip of volcano consisting of fragments of red hot lava |
| Erosion | The process of wearing away |
| Geology | A science that deals with the history of the earth and its life expecially as recorded in rocks |
| Glacial period | Referring to the time when a large portion of the earth was covered with ice |
| Hydro-explosion | Explosions caused by a substance coming into contact with water |
| Lagoon | A pond that is near to a large body of water |
| Post | After |
| Sediments | Materials deposited by water or wind |
| Shield volcano | A broad turtle backed mountain formed by eruptions of lava on the sea floor |
| Subaerial | Something that happens on, or next to, the surface of the earth |

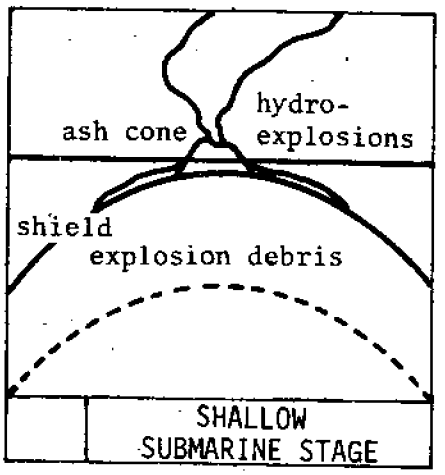
## INSTRUCTIONS

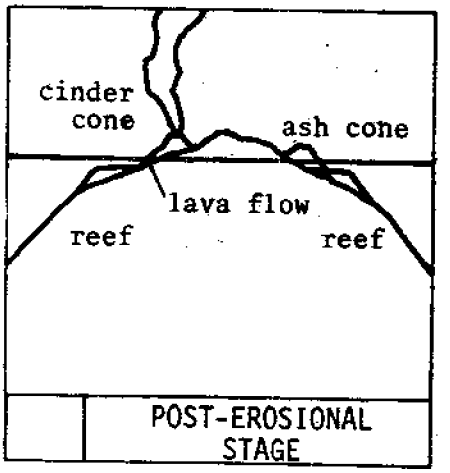
There are nine stages in the life history of an island. Look at the following pictures and using what you have learned from reading about the geology of the Hawaiian Islands, put them in sequence by marking the correct number in the box at the bottom left hand corner of the picture. (Answers on page 31)

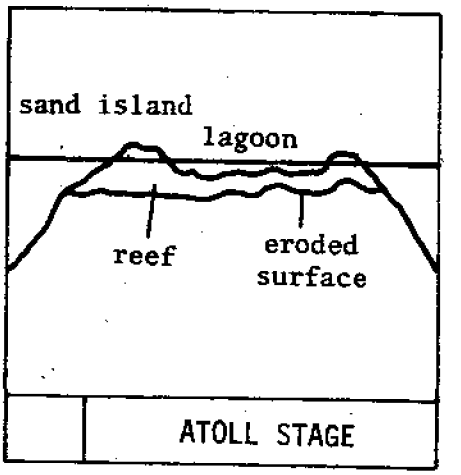


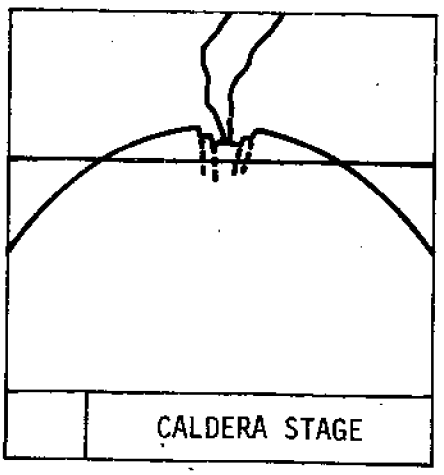



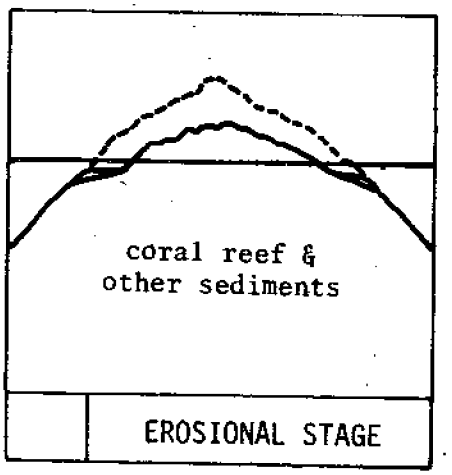



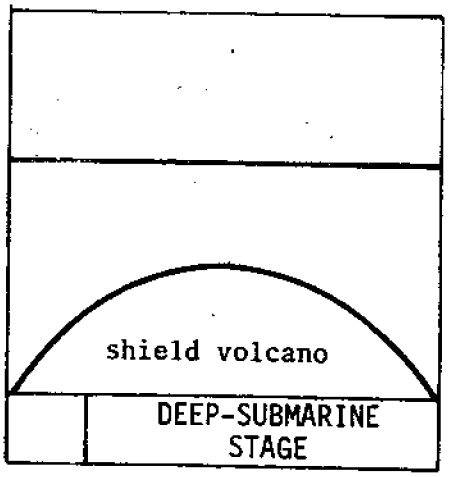



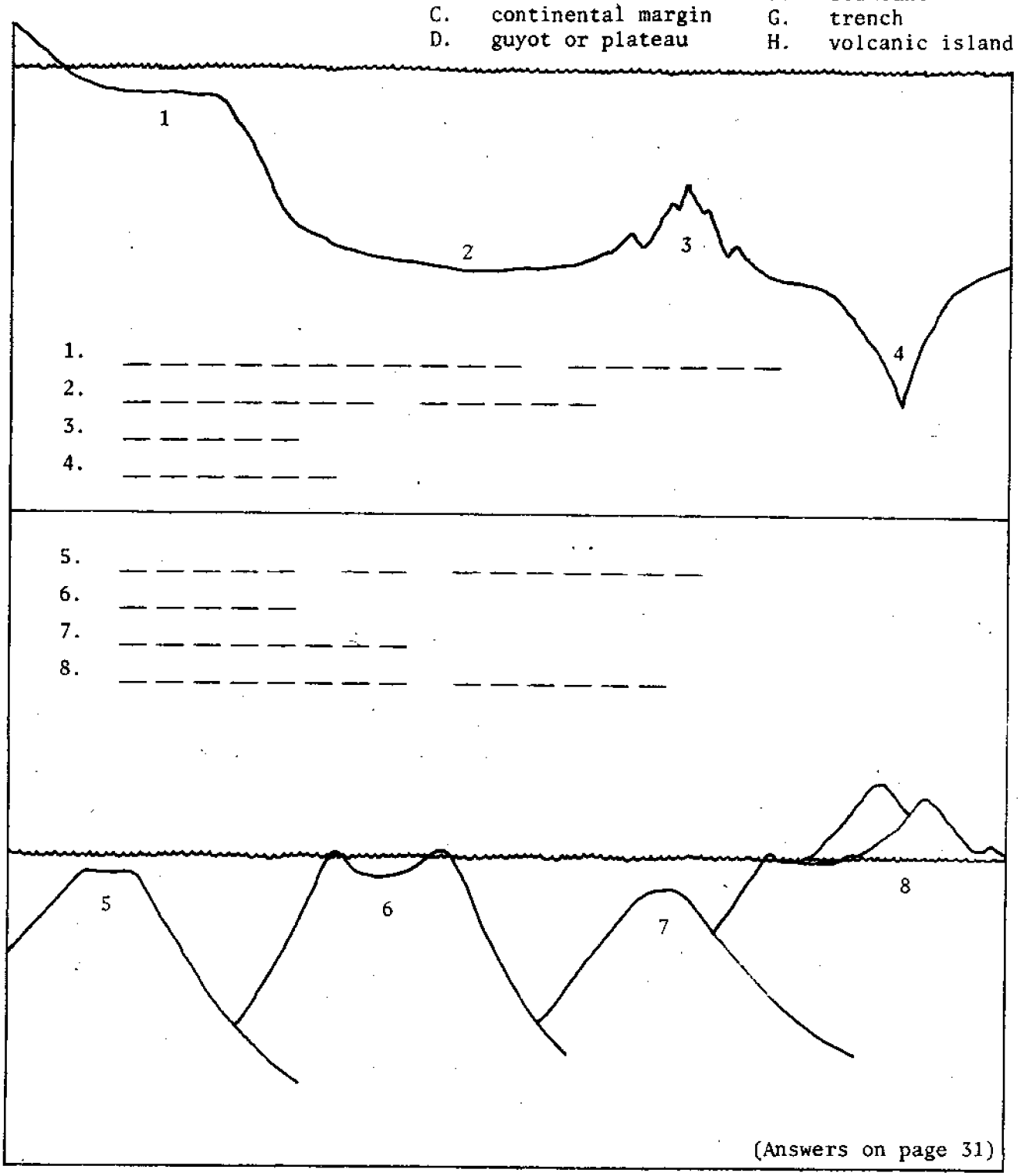



# UNDERWATER FORMATIONS

Find and label the underwater formations listed below:

| | | | |
|---|---|---|---|
| A. | abyssal plain | E. | ridge |
| B. | atoll | F. | seamount |
| C. | continental margin | G. | trench |
| D. | guyot or plateau | H. | volcanic island |




(Answers on page 31)

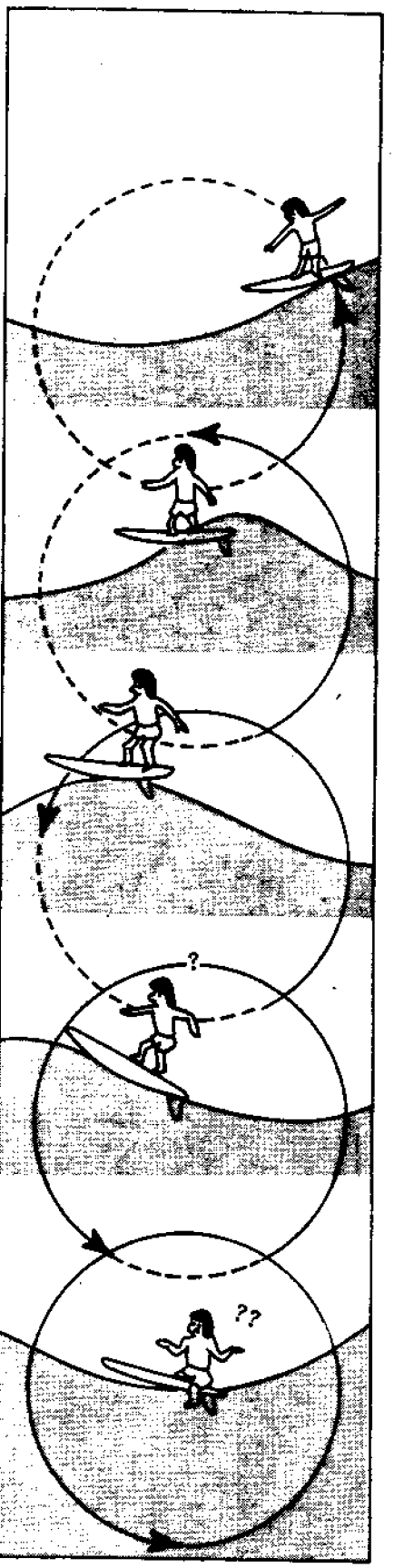
# WAVES

The energy that makes waves comes from (1) WINDS that blow across the ocean, (2) STORMS out at sea, and (3) MOVEMENTS of the SEA FLOOR. The waves you see breaking at the beach are usually made by the trade-winds.

The lowest part of a wave is called a TROUGH, the highest part is called the CREST. The WAVE HEIGHT is the distance between the trough and crest. If the surf report says the waves are breaking three to four feet, it is the wave height that is being measured. WAVE LENGTH is the time it takes for two crests to pass one spot.

Not all of the wave is above the surface. The wave energy goes down from the crest to the trough. The water itself in the open ocean does not move forward, only the energy of the waves moves. The diagram, at the right, shows the energy building up (1 and 2) and peaking as a wave crest (3); then, the energy passes on and causes a crest to drop (4) and creates a trough (5). The surfer will feel like he is on a swing--moving but going nowhere. However, when the wave nears the shore and touches the sea bottom, it starts to drag. This forces the water to pile up until the face becomes so steep that it spills over, or BREAKS. Then the water moves toward shore and takes the surfboard with it.

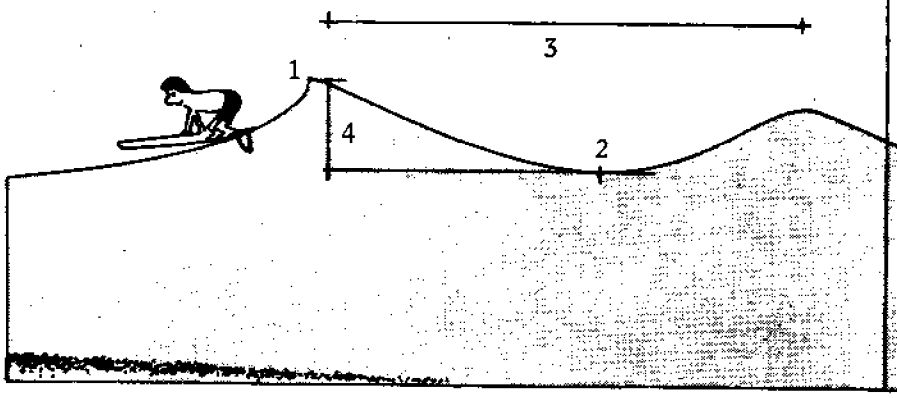
In the diagrams on the right, what is happening to the surfer to paddled out too far? Will he be able to catch a wave out there? Where would be the best place for him to be?




DIRECTIONS

Name the parts of a wave: (Answers on page 31)

1. _____
2. _____
3. _____ _____
4. _____ _____



# TUNA AS A WORLD RESOURCE

Did you know that the well-known Hawaiian tuna, aku or skipjack, is not the only variety of tuna?

The family name of tunas is *Thunnus*. The most common tunas in the Pacific Ocean are: albacores, big-eyes, yellowfin, bluefin, and skipjack. The Hawaiian name for the first four species is ahi. Tunas vary in size from 100 cm (aku) to 300 cm (bluefin).

## CHARACTERISTICS OF THE DIFFERENT TUNAS

Albacore *(Thunnus alalunga)*

Albacores are found at depths of about 150 m in abundance in the Northern and Southern Pacific, Indian, and Northern and Southern Atlantic Oceans, and the Mediterranean Sea. They are also found in lesser numbers near the equator.

Big-eye *(Thunnus obesus)*

These medium-sized fish, about 180 cm in length, are found in cool temperatures at about 100-m depths. They are found in the temperate and tropical regions of the Pacific, Atlantic, and Indian Oceans. Big-eyes are most often found in the currents bordering the sub-tropical counter current and the tropical cold current.

Yellowfin *(Thunnus albacares)*

Weighing nearly 500 kg, bluefins are about 300 cm long and are found close to the surface of the ocean. They are found in the temperate zones of the Northern Hemisphere to the sub-Arctic in the Pacific and the Atlantic Oceans. They are also found in the Mediterranean and Black Seas, and on both the eastern and western waters off Japan.

Skipjack *(Katsuwonus pelamis)*

This heavily fished tuna 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 and the upper regions of South America; off the coast of Africa in the Atlantic Ocean and around the Hawaiian Islands.

## FISHING METHODS

Fishing methods are related to the depth at which fish are usually found and the behavior of the fish.

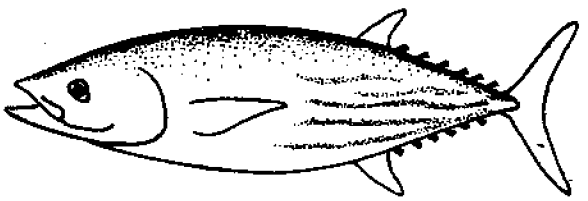
Albacore are caught by longline and pole and line.

Big-eye are caught by longline fishery.

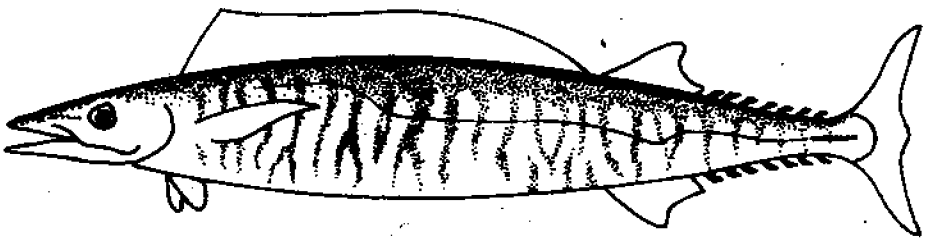
Yellowfin and bluefin are caught by pole and line and purse seine in shallow depths and longline in median depths.

Skipjacks are caught by pole and line in Hawaii and the Trust Territory and purse seine in California.

# COMMON VARIETIES OF TUNA

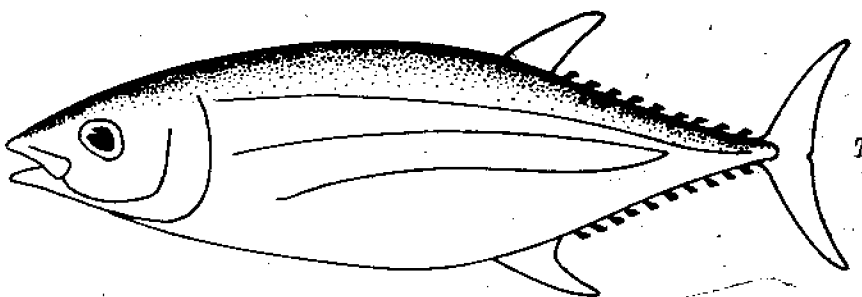


*Katsuwonus pelamis*
SKIPJACK
AKU

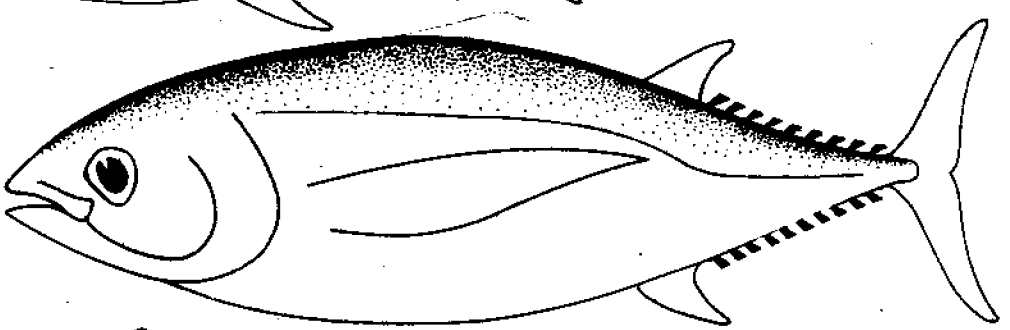


*Euthynnus yaito*
BONITO
KAWAKAWA

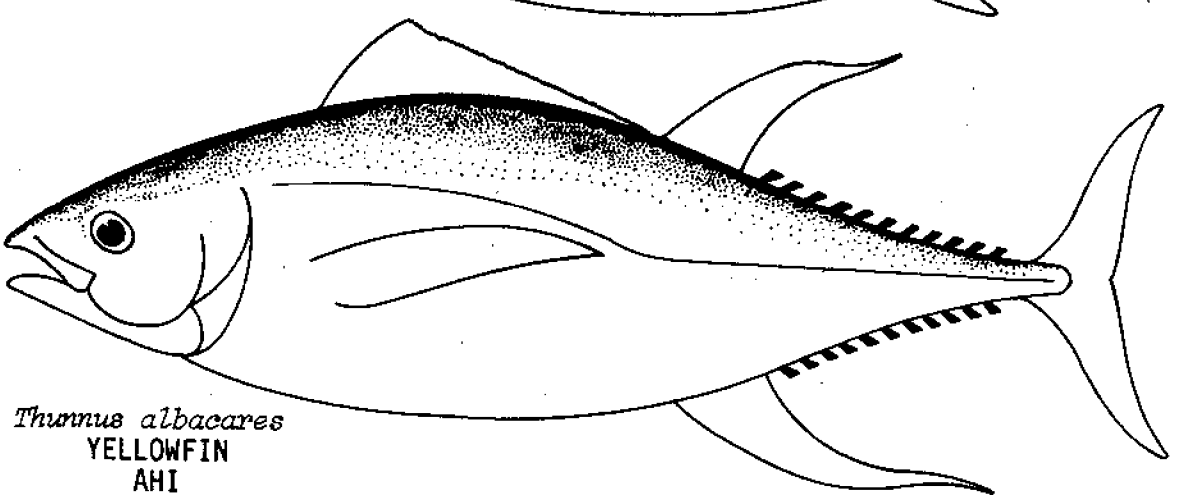
*Acanthocybium solandri*
WAHOO
ONO



*Thunnus alalunga*
ALBACORE
AHIPAHALA



*Thunnus obesus*
BIGEYE
PO'O-NUI



*Thunnus albacares*
YELLOWFIN
AHI

# AQUACULTURE

## -- Macrobrachium rosenbergii

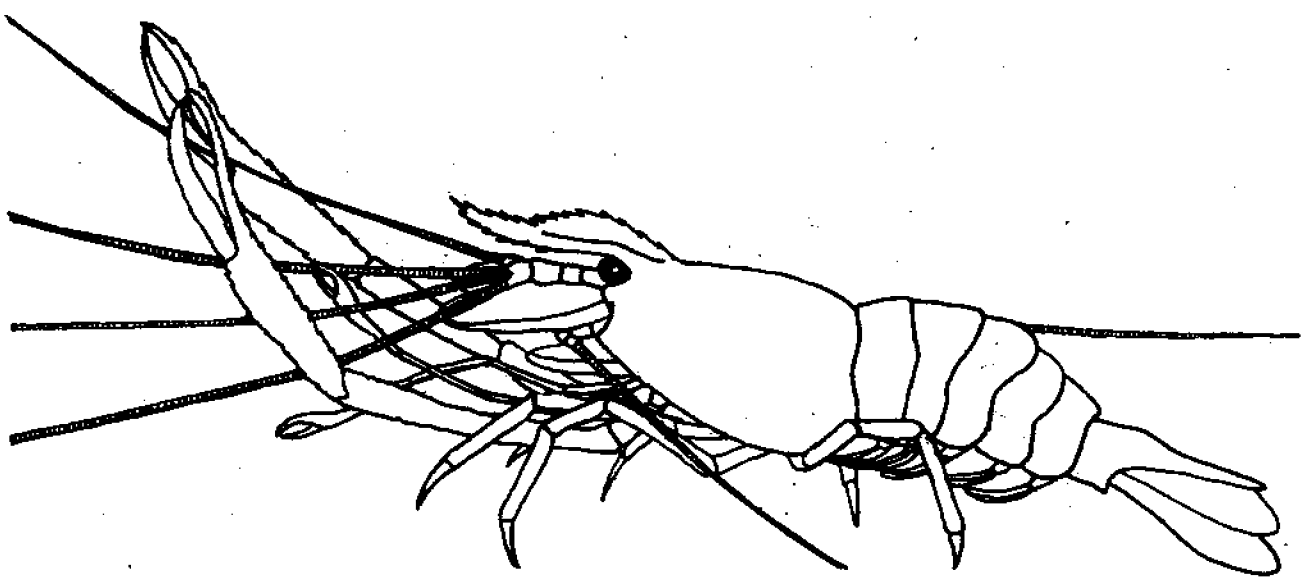
The Malaysian prawn, *Macrobrachium rosenbergii*, is widely distributed in most of the tropical and sub-tropical areas of the Indo-Pacific region. It occurs the whole year round and is present in both fresh and brackish waters. It is usually found in the lower reaches of rivers but is also present in lakes, mining pools, and paddy fields.

This prawn differs from the Tahitian prawn, *Macrobrachium lar* which is commonly found in Hawaii. It is believed that the Tahitian prawn which was introduced in 1959 established itself in Hawaii because its larval stage requires salt water, whereas the larval stage of the Malaysian prawn requires brackish water. Since Hawaii resembles Tahiti geographically, in that rivers empty directly into the oceans making brackish water rivers not as common as in Southeast Asia, the Malaysian prawn although introduced has never established itself. The temperature in Hawaii is also too low for the larval stages of the Malaysian prawn.

Common items of food include aquatic worms and insects, fish, other animals, grains, seeds, nuts, fruits, algae, and other plants. The diet of cultured prawns in Hawaii are supplemented by broiler starter (chicken feed) and processed shrimp shells.

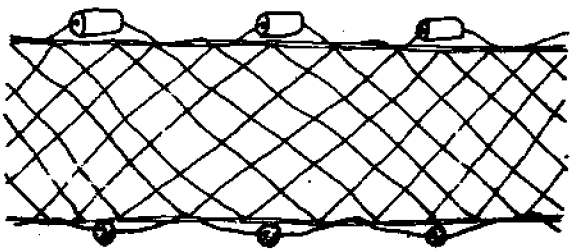
After maturity, the prawns will produce eggs as frequently as every month. At each mating, there are as many as 7,000 to 20,000 eggs which are incubated on the tail section for 20 to 25 days.

After hatching, larvae are raised in brackish water at Anuenue Fisheries for 35 days. Optimum temperature is 85 to 88°F. The larvae are fed aku and newly hatched brine shrimp. When larvae metamorphose into juveniles, they can be put into freshwater. It is at this stage, the young juveniles are put into earthern ponds located in various places around the state. They will take 5 to 9 months to reach marketable size and are frequently found in Hawaii markets, six to nine prawns selling for $5.00/lb.



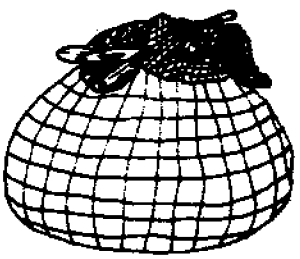
# FISHING IN OLD HAWAII

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



1. 'upena ku'u

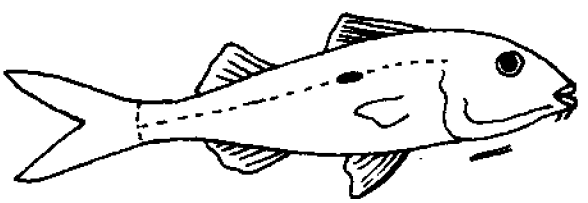
a. he'e



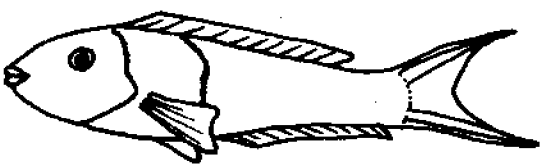
2. hīna'i

b. 'ōpū hue

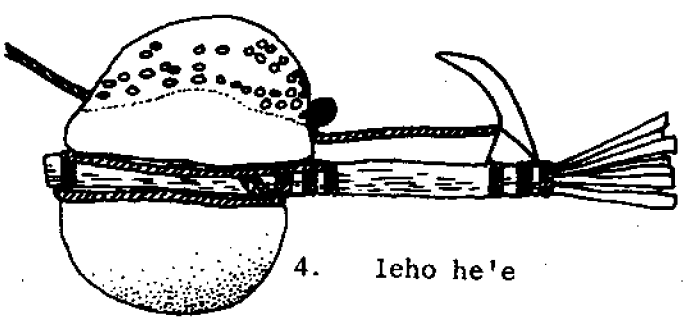
3. 'oi'a



c. weke 'ā'ā

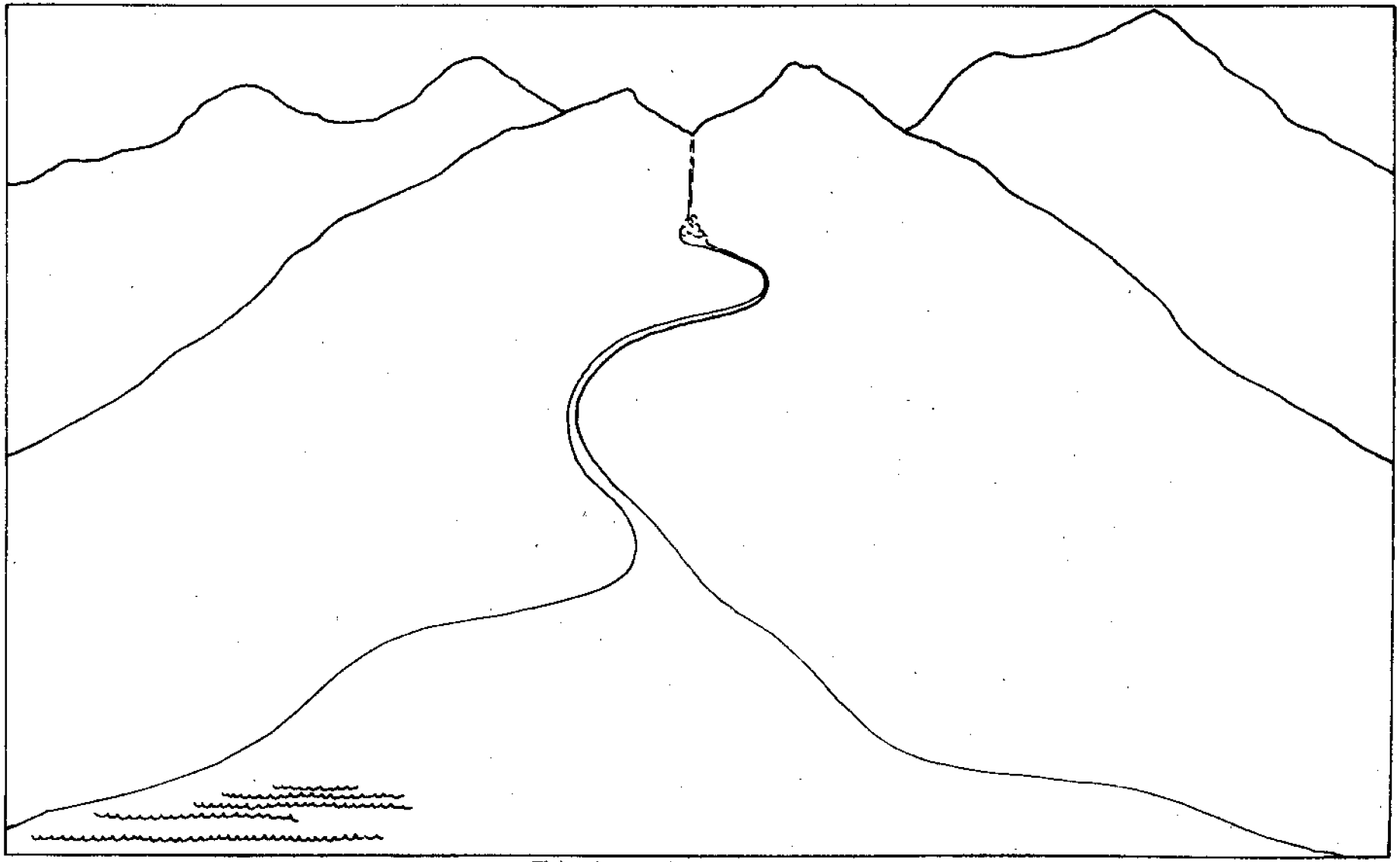


d. hinalea



4. leho he'e

(Answers on page 31)



# AHUPUA'A

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 this 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.

# BICENTENNIAL OF COOK'S ARRIVAL

On January 18, 1778, Capt. James Cook (1728-1779) sighted the islands of Kauai and Oahu and named the group of islands the Sandwich Islands after his patron the Earl of Sandwich.

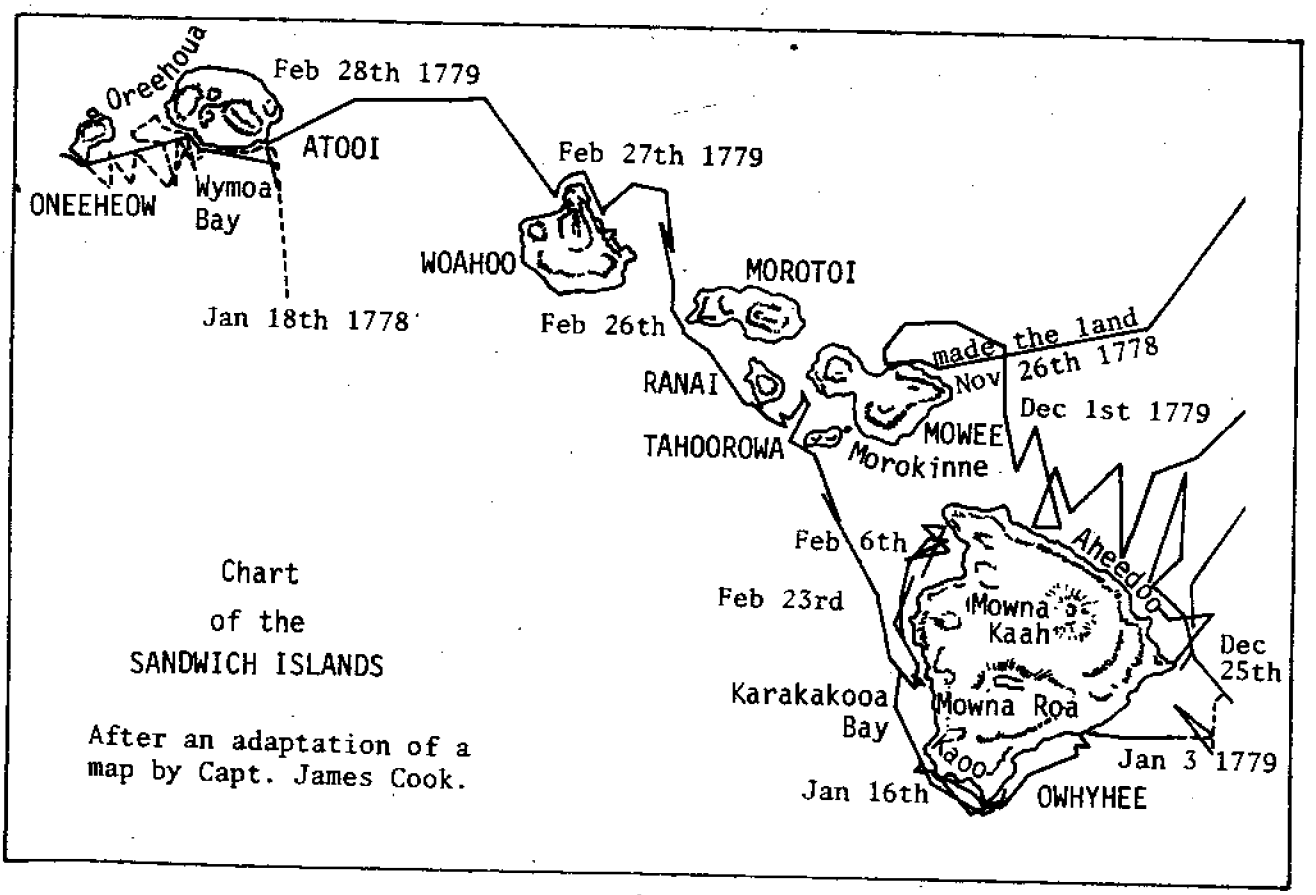
Capt. Cook was on his third exploration voyage to the Pacific. On this trip, he was in search of a Northwest Passage from the Pacific to the Atlantic Ocean.

On January 19, he led his ships, the *Resolution* and the *Discovery*, along the coast of Kauai, where he found a safe anchorage and fresh water. The Hawaiian natives thought he was their god Lono and bowed before him.

After taking on water and food, Capt. Cook continued his voyage in search of the Northwest Passage. He passed through the Bering Strait but was soon blocked by ice and was forced to turn back.

He returned to Hawaii where he was received kindly at Kealakekua Bay, Hawaii. However, due to a misunderstanding, Capt. Cook was killed on February 13, 1779.

Capt. James Cook was probably the greatest of the Pacific explorers. He made true and clear maps of places already discovered in addition to those he discovered. Although his arrival is recognized as the first European discovery of the Hawaiian Islands, some accounts credit Spanish explorer Juan Gaetano with being the first European to discover the Hawaiian Islands in 1542 on his way to the Philippines. Regardless, Capt. Cook made his discovery known to the world and his arrival marked the beginning of the coming of westerners to our island shores.



# COOK'S VOYAGE

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.

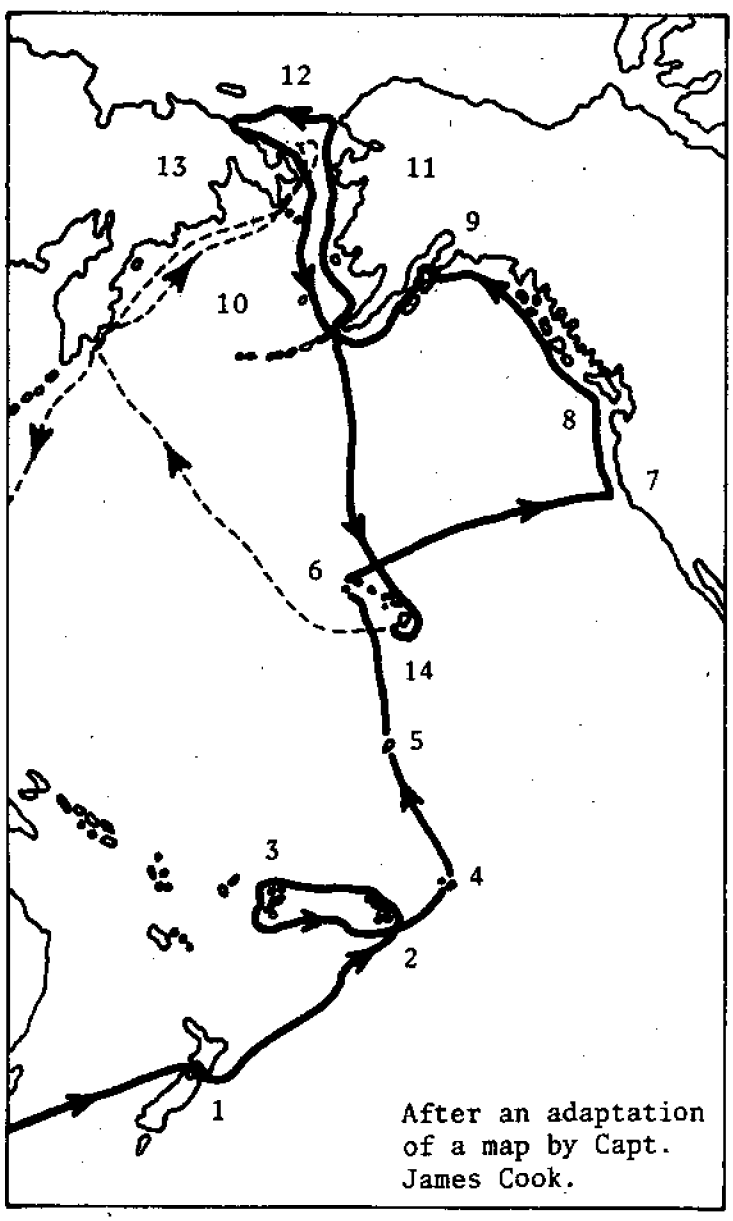
LIST OF PLACES

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

DIRECTIONS

Fill in the MAP KEY below. Use the names from the LIST OF PLACES (left).

(Answers on page 31)




After an adaptation of a map by Capt. James Cook.

MAP KEY

1. _ _ _

_ _ _ _ _ _ _ _

2. _ _ _ _ _ Islands

3. _ _ _ _ _ _ _ _ _

Islands

4. _ _ _ _ _ _

5. C h r i s t m a s

Island

6. _ _ _ _ _

7. _ _ _ _ _ _ _ _ _ _

8. _ _ _ _ _ _ _ _ _ _

Island

9. _ _ _ _ _ _ _ _ _ _

10. _ _ _ _ _ _ Sea

11. _ _ _ _ _ _

12. _ _ _ _ _ _ _ _ _

13. _ _ _ _ _ _ _

14. _ _ _ _ _ _

# WHALE FISHERY
## -- a history

Man has been hunting WHALEs (20D) far back into RECORDED HISTORY (14A). The earliest period of whaling dates back to the 12th century.

EUROPE (8D). The BASQUEs (11A) at first used STRANDed (5D) whales, but soon after began to go out to SEA (13A) with small boats to hunt the RIGHT (16D) whales.

In the early 17th century the DUTCH (31A) discovered the ISLAND (17A) of SPITZBERGEN (2A) and the rich whaling grounds around it. The Dutch built shore STATIONS (12D) and competed with the ENGLISH (3D) for the valuable oil and baleen of the GREENLAND (23D) right and BISCAY (11D) whales.

ASIA (35A). By the end of the 17th century, the Japanese developed a new way of hunting using NETS (4A) with empty barrels that served as FLOATERS (21A).

South Pacific. Below the EQUATOR (15D) the British, Americans, and FRENCH (21D) hunted whales around NEW ZEALAND (19A).

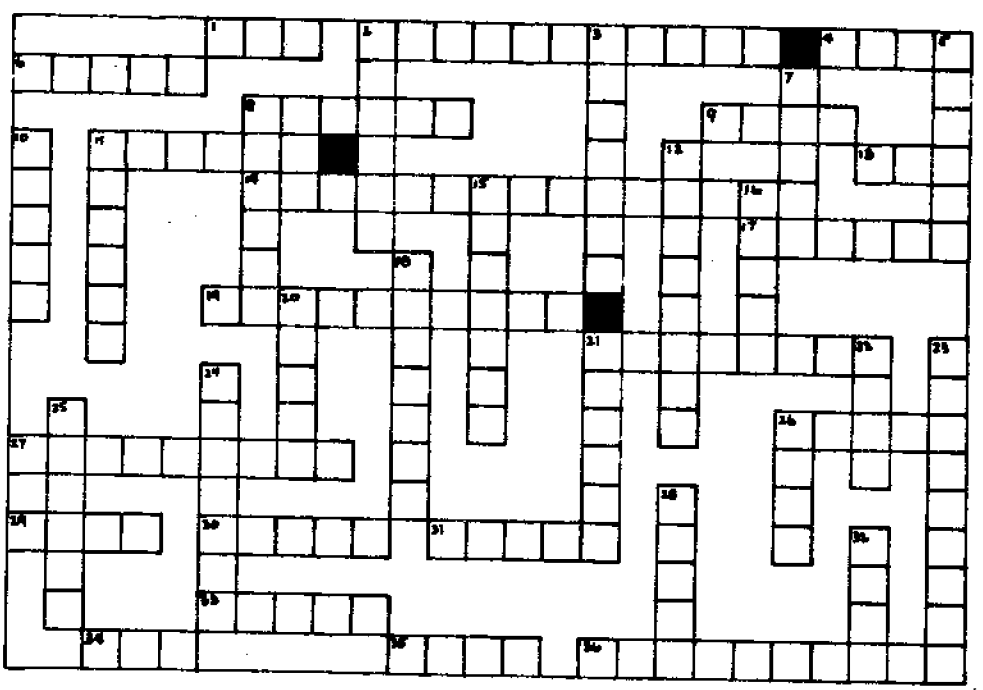
North America. The Aleutian ESKIMO (8A) started whaling about the same time as the Basques. They would use their kayaks with double-ended PADDLES (18D) to quietly sneak up on the whales.

Some west coast Indian tribes in America hunted the California GREYS (7D) in the bays of BAJA (32D) California. In NEW ENGLAND (36A) Indian tribes used a fleet of BARK (29A) CANOEs (33A) and bows and ARROWs (28D) to hunt. "DRIFT (6A) whales," which were dead or stranded whales, were highly prized in the Massachusetts BAY (34A) area.

In 1712, SPERM (10D) whales were found to contain valuable spermaceti. To chase these whales New England whalers began building larger vessels equipped with TRYworks (1A) to boil the blubber. SHIPs (22D) from NANTUCKET (27A) journeyed to Cape HORN (9A) and into the PACIFIC (24D) and to CHILE (26A). A FLEET (30A) of ships, each carrying a CREW (26D) of 40, transferred whale oil to cargo ships in ports like HAWAII (25D). At the height of the whaling industry, 70,000 SAILORs (2D) were employed.

DIRECTIONS

Read the "History of the Whale Fishery" and complete the crossword puzzle.



# MAMMALS

Animals are either INVERTEBRATES, animals without a backbone, or VERTEBRATES, animals with backbones. Mammals are VERTEBRATES. Other vertebrates are fish, amphibians, reptiles, and birds. There are 20 other ORDERS, or groups, of mammals, only four of which are marine mammals.

How are mammals different from the other vertebrates?

ANIMALS

INVERTEBRATES

VERTEBRATES

FISH | AMPHIBIANS | REPTILES | BIRDS | MAMMALS

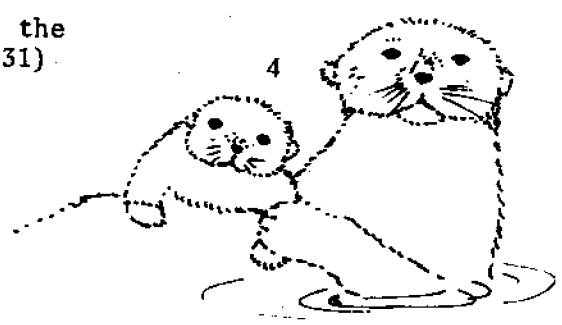
Mammals have:

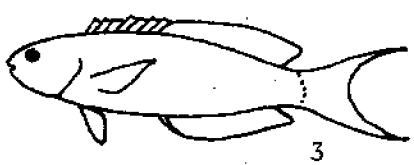
1. "true" hair to keep the body warm
2. mammary glands to produce milk to feed their young
3. a large developed brain
4. three bones in the inner ear
5. a diaphragm which helps to push air into the lungs
6. a lower jaw made of one bone


1

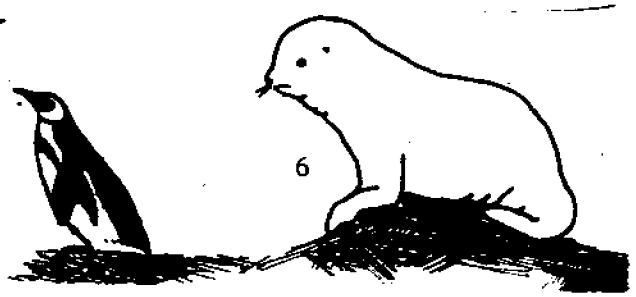
DIRECTIONS

Draw a circle around all the mammals. (Answers on page 31)


4


3


2


5 6

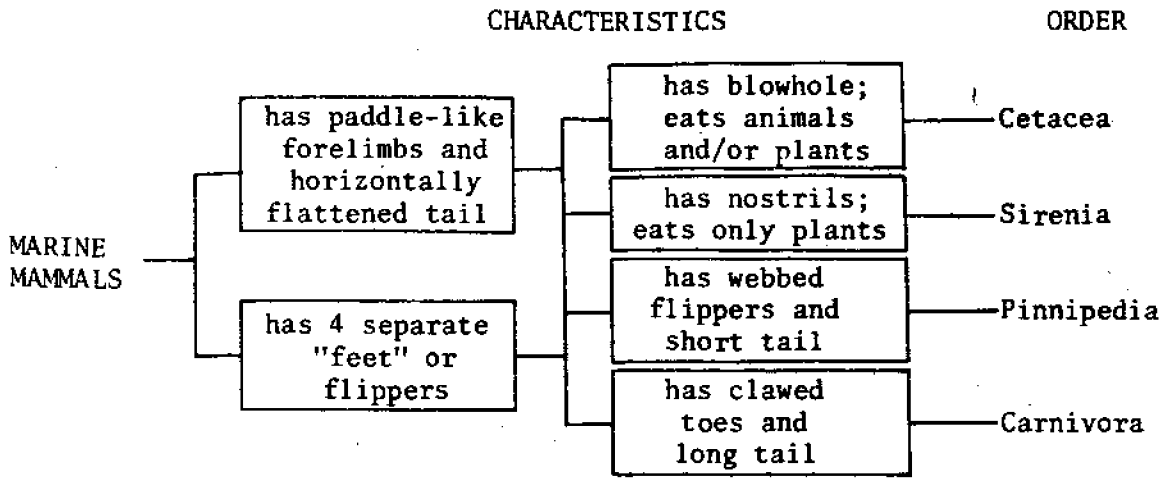
# MARINE MAMMALS

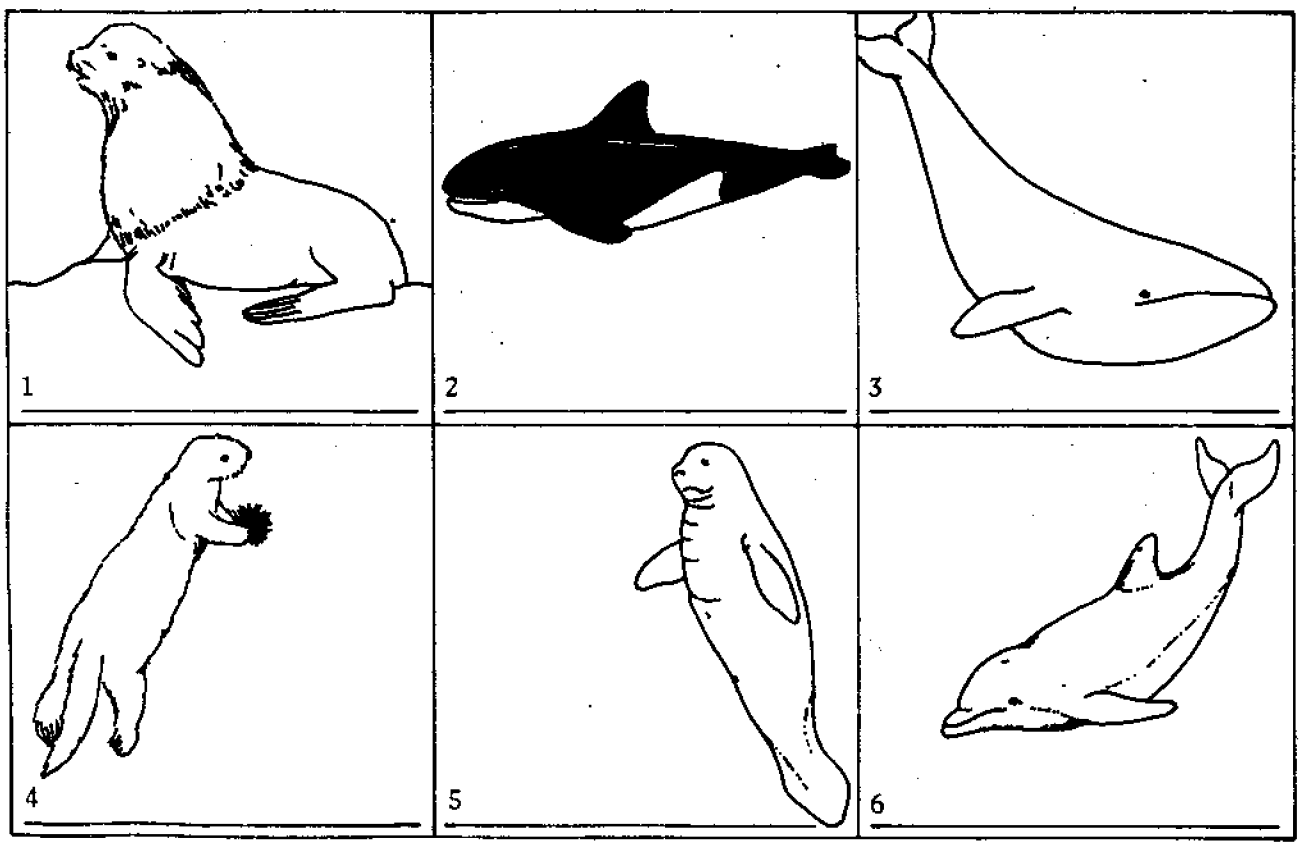
Mammals are divided into 20 different ORDERS, or groups, according to how they are alike. For example, human beings and apes below to the PRIMATE ORDER and horses and zebras are placed in the PERISSODACTYLA ORDER.

Marine mammals are classified into four ORDERS: a) CETACEA, b) SIRENIA, c) PINNIPEDIA, and d) CARNIVORA.

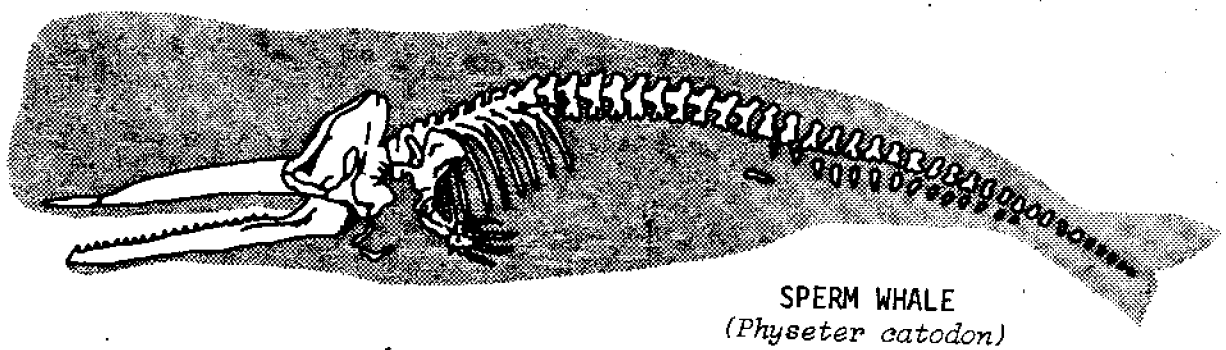
## DIRECTIONS

Look carefully at the drawing of the marine mammals below. Using the following chart place each into the correct ORDER and write the name of the ORDER in the blank below each animal. (Answers on page 31)



# TOOTHED WHALES



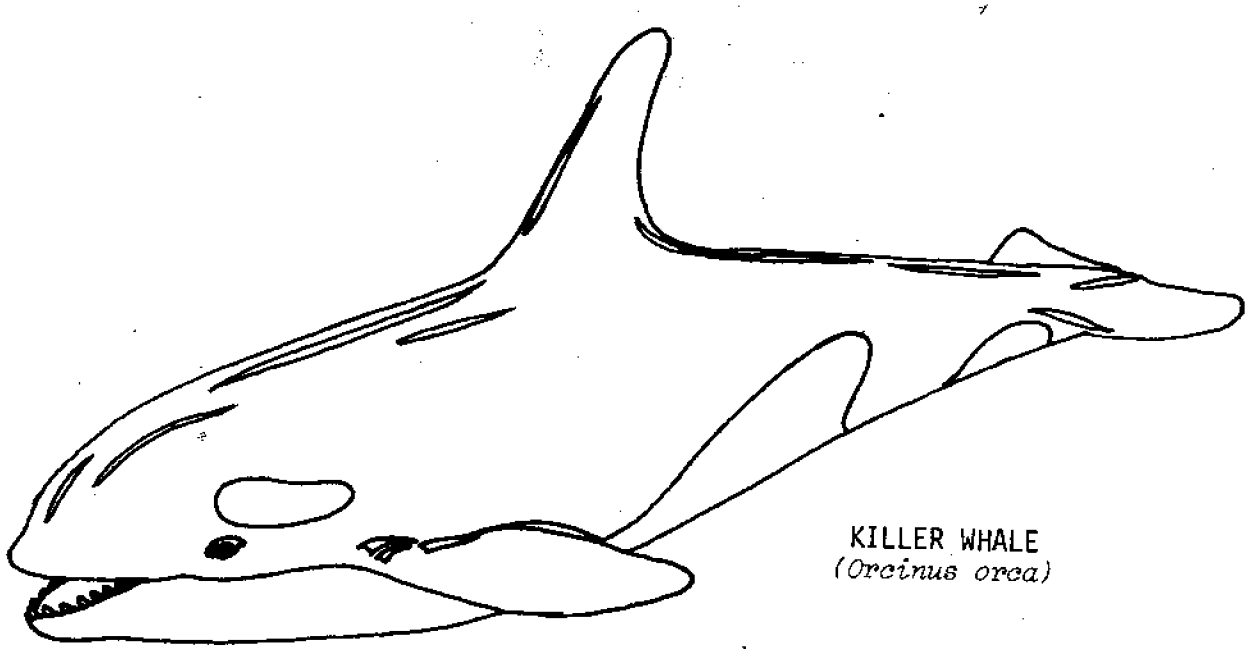
SPERM WHALE
*(Physeter catodon)*

Most of the cetaceans are toothed whales which range in size from the 1-m dolphins and porpoises to the 18-m sperm whales, *Physeter catodon*.

Toothed whales have 2 to over 200 teeth in either or both jaws. How big the cetacean is does not determine how many teeth it has. The 11-m bottlenose whale, *Myperoodon ampullatus*, has only 2 teeth while the 1.5-m La Plata river dolphin, *Steno delphis blainvilli*, has 210 to 240 teeth in two rows.

The number of teeth whales have usually determines what they eat. Cetaceans which have many teeth, such as porpoises, are able to catch slippery, active fish, while cetaceans which have just a few teeth are able to catch and hold only squid and less active fish. The sperm whale, which feeds on deepsea squid, has 18 to 24 teeth on each side of the lower jaw.

Toothed whales feed mainly on squid and fish. Killer whales, *Orcinus orca*, however, eat sea otters, seals, birds, and other whales (some of which are bigger than the killer whale itself), in addition to squid and fish.



KILLER WHALE
*(Orcinus orca)*

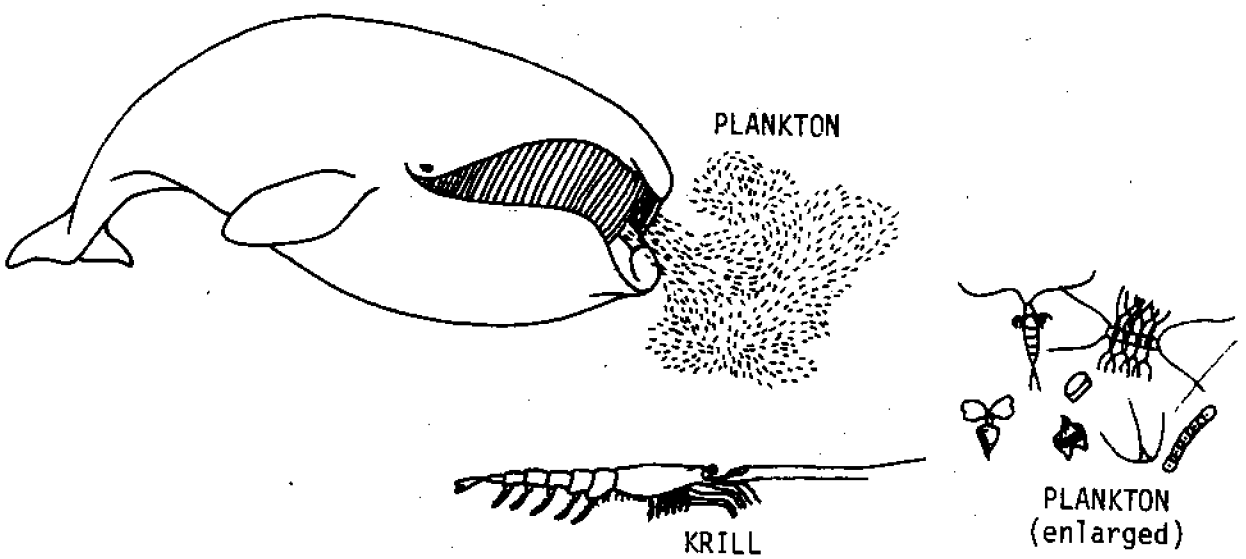
# "TOOTHLESS" WHALES

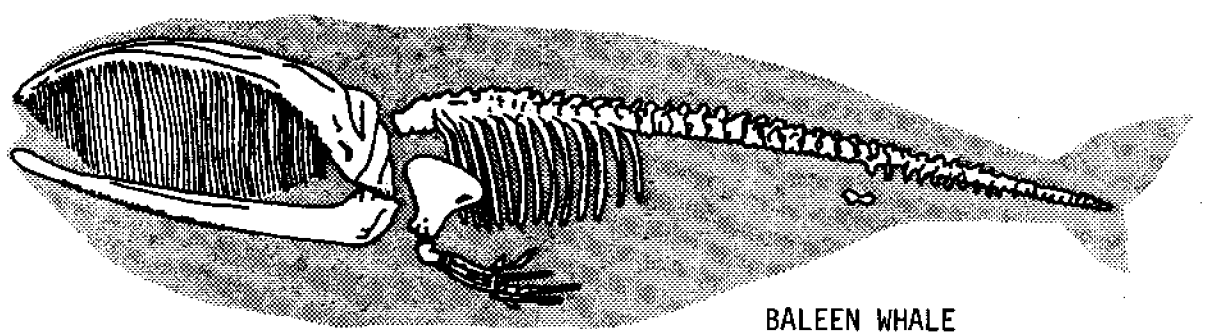
Unlike most whales which have different numbers and kinds of teeth, baleen whales have no teeth. They are "toothless."

Baleen whales, therefore, do not eat fish, squid, or other seafood which require chewing. Instead, they feed on plankton, tiny marine plants and animals, which can be swallowed whole.

The baleen whale uses hundreds of baleen plates hanging from the roof of its mouth to eat. Each baleen plate is frayed on the inside edge. When all of the plates are placed next to each other, they form a tangled mass which is used to capture food. Thus, when feeding, the baleen whale opens its mouth to take in seawater and plankton. It then closes its mouth, using the tongue to push the seawater through the baleen plates, leaving the filtered plankton to be swallowed.

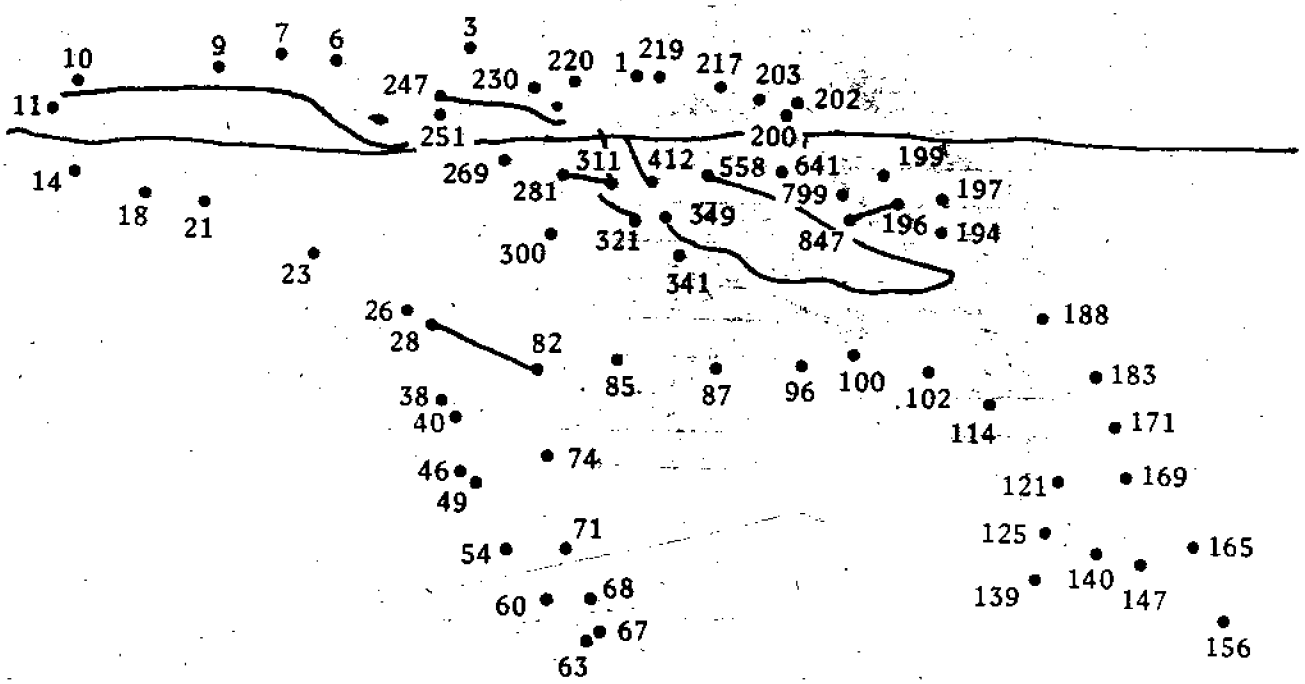
The blue whale, *Balaenoptera musculus* (30 m), which is the largest mammal, and the humpback whale are examples of baleen whales.



# HUMPBACK WHALE PRESERVE

In 1976, the humpback whale was adopted by the Hawaii State Legislature as the official marine mammal of our state. Not long ago, waters between Maui, Lanai, Molokai, and Kahoolawe were declared the first whale preserve in the US. The proclamation states that the months from December to May will be whale reserve months in the county of Maui to protect the endangered humpback whales. These whales migrate to Hawaii from the North Pacific each winter to breed. During the winter months the babies are born. It is really important not to bother the whales because this is when they teach the calves to breathe on the surface and hold their breath underwater.




## DIRECTIONS

Connect the dots and find the meaning of the words below.

## WORD LIST

adopted

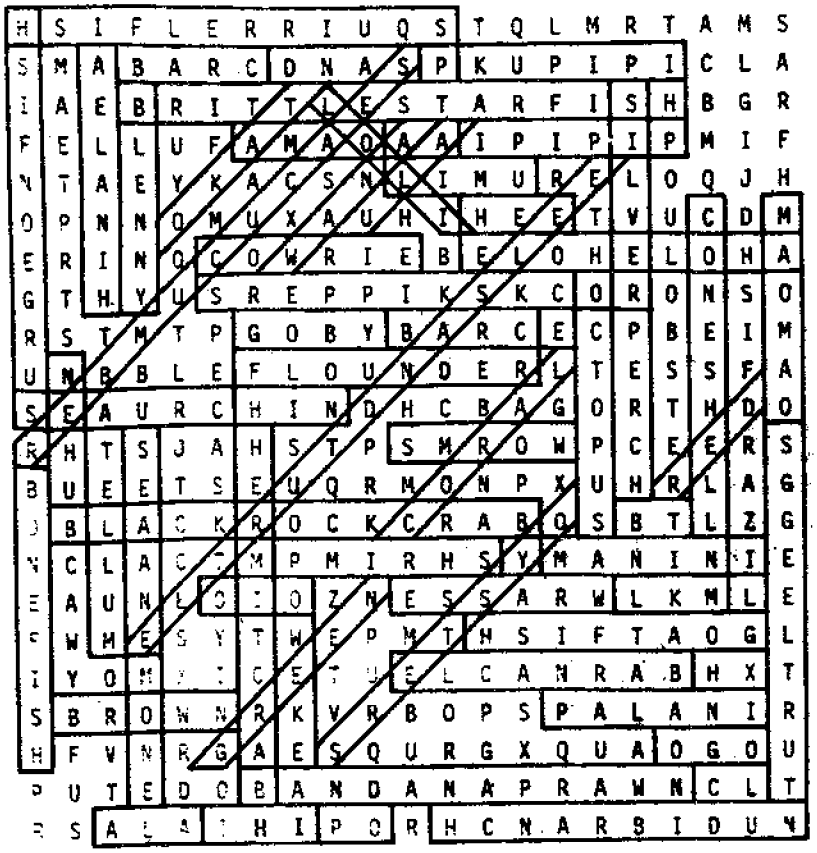
preserve

proclamation

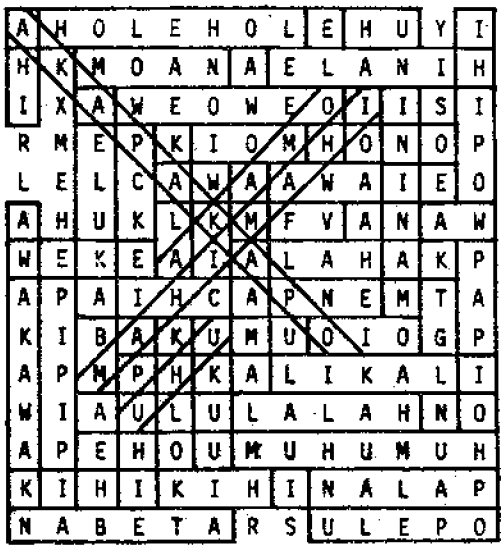
endangered

# CHEAT SHEET

p. 4



p. 7



p. 9

1. INVERTEBRATES
2. VERTEBRATES
3. INVERTEBRATES
4. INVERTEBRATES
5. VERTEBRATES
6. VERTEBRATES

p. 10

| |
|---|
| 4 |
| 2 |
| 1 |
| 3 |
| 5 |

p. 11

1. PHYTOPLANKTON
2. PRIMARY PRODUCERS
3. SUNLIGHT
4. NUTRIENTS
5. ZOOPLANKTON
6. FIRST ORDER CONSUMERS
7. BALEEN WHALE
8. SMALL FISH
9. THIRD
10. FOURTH
11. FOURTH

p. 12

1. GREAT WHITE
2. HAMMERHEAD
3. TIGER
4. DOGFISH

p. 15

| | | |
|---|---|---|
| 3 | 5 | 7 |
| 2 | 8 | 9 |
| 4 | 6 | 1 |

p. 16

| | |
|---|---|
| 1. C | 5. D |
| 2. A | 6. B |
| 3. E | 7. F |
| 4. G | 8. H |

p. 17

1. CREST
2. TROUGH
3. WAVE LENGTH
4. WAVE HEIGHT

p. 21

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

p. 24

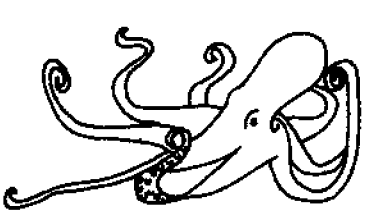
1. NEW ZEALAND
2. COOK
3. FRIENDLY
4. TAHITI
5. CHRISTMAS
6. KAUAI
7. NEW ALBION
8. VANCOUVER
9. COOK INLET
10. BERING
11. ALASKA
12. ARCTIC ICE
13. SIBERIA
14. HAWAII

p. 26

2, 4, and 6 are mammals

p. 27

1. PINNIPEDIA
2. CETACEA
3. CETACEA
4. CARNIVORA
5. SIRENIA
6. CETACEA



# ACKNOWLEDGMENTS

The continued support of the State Office of the Marine Affairs Coordinator for Makahiki Kai is gratefully acknowledged. Such support is provided, not only as funding, but also as encouragement for the public education effort represented by Makahiki Kai. The invaluable support of Spencer Malecha, the Waikiki Aquarium, Wendy Nakano, Mike Tsukamoto, and Karen Tanoue is also acknowledged.

# SEA GRANT OVERVIEW

The enactment of the Sea Grant College Program Act of 1966 envisioned the creation of a network of sea grant colleges in institutions of higher education across the country which would parallel land grant colleges.

"Sea Grant College" is a designation that is earned by a university when it proves that it has the capability of carrying on comprehensive programs on marine-related research, education, and advisory/extension programs--the three-pronged mission of the Act. The University of Hawaii became a Sea Grant College in 1972, culminating four years of program building.

In 1979-80 Sea Grant funds of $1.6 million, matched by nearly $.9 million in state and other local funding, have enabled university-based experts to carry on research in:

- marine resources development (projects on aquaculture of plants and animals
- socio-economic and legal studies (projects on ocean law, marine economics
- marine technology research and development (projects on ocean engineering
- marine environmental research (projects on coastal pollution and monitoring)

The second Sea Grant program area, education and training, has ongoing and new projects to develop curricula and programs for lower education, undergraduate, graduate, and community college levels.

The third major mission of the Sea Grant College Act is being fulfilled by the establishment of a statewide marine advisory program to transmit information on a timely basis to all users.

*This workbook is published by the University of Hawaii Sea Grant College Program under Institutional Grant No. NA79AA-D-00085 from NOAA Office of Sea Grant, Department of Commerce, with funding provided by the State Marine Affairs Coordinator's Office under Task Order No. 197. The US Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notations that may appear hereon.*




UNIVERSITY OF HAWAII