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Makahiki Kai

festival of the sea '77

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TEACHERS' GUIDE

Makahiki Kai '77 marks the fourth year of the "festival of the sea" and in developing the four oceanic environments that this year's exhibits depict, a very personal relationship between the youngsters and the ocean is being suggested. The theme for this year is: Me and the Sea. (Child: "Hello, sea, who are you?") Sea: "Come, explore.")

The four environments within which we have grouped displays are: the land-sea-interface; the Hawaiian seashore--benign and harsh; the beautiful Hawaiian reef and reef communities; the deep, deep blue waters, the home of big animals; and the darkest depths where no light penetrates and where the inhabitants are bioluminescent and strange and wonderfully shaped.

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The Makahiki Kai '77 exhibits are a series of self-standing display boards which depict the environment and in graphics show concepts of adaptability, inter relationships between animal and animal and animal and environment, methods of protection, physical oceanographic facts, the ocean's resources as an economic base, and safety hints for sea and shore enthusiasts.

We will make every effort to provide guides to explain the exhibits and interact with your students. However, as you well know, excursions can be truly meaningful to students only if they have been prepared sufficiently on the subject of the exhibits. It is our hope that you will take some time to look over the material we have prepared to aid you in enriching your students orientation to the ocean prior to their visit to Makahiki Kai '77.

Please feel free to send back to us any comments, good or otherwise, that you might have on this guide. We can only improve by receiving input from you. Please address all comments to:

Rose Pfund, Coordinator
Makahiki Kai
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2540 Maile Way, Spalding 253
Honolulu, Hawaii 96822

Mahalo. We hope you and your class will enjoy your visit to Makahiki Kai '77. Please let us hear from you so that the next Makahiki Kai will be even better.

Rose Pfund, Coordinator
Makahiki Kai '77

OUR HAWAIIAN SEASHORE

The Hawaiian coast is a constantly changing motion of shapes: a blend of the black rocky Hamakua coastline to the beach at Hanalei. From white sand to green sand, the beaches of Hawaii are unique places. Each is a community inhabited by marine animals and plants that are specially adapted to their environment. At some coastal areas, the waves gently ebb and flow but at others the waves race shoreward and crash against the black lava rocks.

OUR HAWAIIAN REEF

The world-famous reefs of Hawaii are an explosion of color and life. Gaudily painted wrases and damselfish dart among the fingers of coral while giant manta rays cruise slowly overhead. The reef is a strange community where predator and prey often cooperate in strange but necessary "mutual aid societies." But some animals rely on special weapons for protection while others have adapted so well to their environment that it is often very hard to spot them.

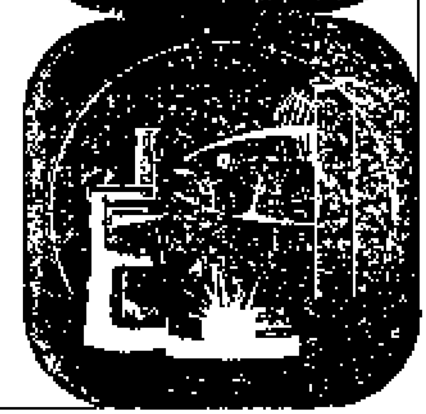
DEEP BLUE WATERS

The world's most complex and largest rivers are not on land but at sea. Great current systems circle the world. Within the many layered waters of the ocean, large deepwater fishes and mammals live and move about in pursuit of food. It is estimated that many thousands of pounds of aku (skipjack tuna) are in Central Pacific waters. The vastness of the ocean makes it impossible to take an accurate census of the inhabitants that live in the deep blue waters.

THE DARKEST DEPTHS

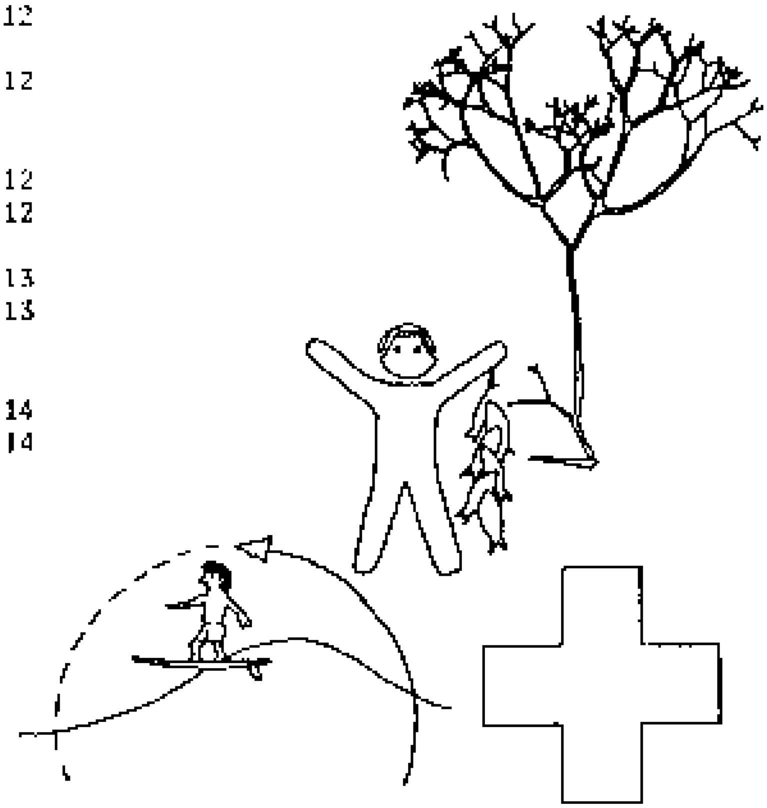
Sunlight reaches down to a depth of 600 feet in clear waters. Beyond that it is pitch black. For a long time it was thought that nothing lived in the abyssal depths of the ocean. When scientists developed subersibles, and it was possible to go down to the bottom of the sea, they discovered that nature had adapted fishes in wonderous ways. Fishes carry their own lanterns and they are small so their bodies can withstand the pressure at the the ocean bottom.

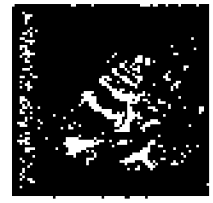
SEALAB



A fun way to experience the wonders of the ocean is to do experiments! It's exciting to be able to touch the animals and plants and find out what they're like. Oceanographers conduct experiments to find out not only the physical properties of the ocean. Research is hard work but it helps us to learn about the ocean and all of its wonders.

OUR HAWAIIAN SEASHORE





I. SHORELINE COMMUNITIES

A. Auwe! Be Careful!

When you go exploring along the shoreline, it's lots of fun, but there are things that can harm you so be on the lookout for them.

Along rocky coasts the waves that break on the rocks can wash you into the ocean. Look for these signs of high waves: tide pools are generally formed by waves crashing on the rocks, snails and pipipis clinging to the sun dried rocks, and salt dried in shallow holes show water level at high tide.

Wet rocks can be very slippery. Wear sneakers and test your footing for slippery or loose "rocking" rocks.

Even at sandy beaches, large waves can wash up the face of a beach and sweep you into the water. Keep an eye on the waves and always be prepared for the unexpected.

Learn to recognize animals along the shore that have ways of protecting themselves that could hurt you. Some of these animals are:

1. Sea urchin, or wana

Sea urchins have sharp pointed spines covering their bodies that can pierce your skin and break off. The black long spined wana has poisonous spines.

2. Coral

Coral cuts can be serious if not cleaned out well.

3. Cone shells

Cone shells hunt other shells with a poison dart. If you must handle them, pick them up by the broad, flat end.

4. Eels, or puhi

Most shallow water eels are shy and hide in holes. They won't bother you if you don't poke a hand or toe or anything else into their holes and bother them.

5. Portuguese man-of-war

B. Rocky Coast

Just beyond the tidal pools is a place called the surge zone, where seawater is always moving. The animals that live here must be strong swimmers or be able to stick to the rocks to keep from being washed away by strong waves.

Most fish found here are baby fish. These fish like the surge because they can play in it and it brings them plankton to eat. Some of the baby fish found here are KUPIPIS, who think the pool belongs to them, SERGEANT MAJOR FISH (MOAMOA or MAMO), who got their name because of the stripes on their body, AHOLEHOLE which are sometimes called SILVER PERCH because of their color, and the red CARDINAL FISH. As these fish grow they will move into deeper water.

Did you know that there are some fishes that graze, like horses and cows do on grassy land? The "grass" in the ocean is called seaweed or limu. Limu- or seaweed-eaters are called herbivores. Baby MANINI and PALANI are the more common fish herbivores. COWRIES, OPIHIS, and TOP SHELLS are also herbivores.

Be extra careful when walking on rocks that are underwater and covered with green "algae slime" and even those which do not seem to have any growth covering them. Some algae are microscopic and rock-brown in color.

An animal that these little fish have to watch out for is the MORAY EEL or PUHI, who comes out of its hole at night to catch fish which are sleeping too soundly. Small TAKO (OCTOPUS) also have to watch out for they are moray's favorite food.

When walking on the reef be sure to wear sneakers or tabi so the moray eel does not mistake your toe for a fish or part of a tako.

There are a number of marine animals that aren't good swimmers or non-swimmers. BRITTLE STARS, WANA or SEA URCHINS, and the SNAKE HEAD COWRIE are good examples. They move about by "walking" on "feet" which are really suction cups. Sea urchins and brittle stars have many little feet, but the cowrie has one large foot. The feet also help these animals to hang on to the rocks when the waves get rough. One type of wana even makes a hole in the coral reef to protect itself.

C. Tidal Pool

Hi, I'm a BLACK ROCK CRAB and my Hawaiian name is AMA. My friends call me Rocky or "the Rock" because even the big waves can't wash me off the rocks. My neighborhood here along the rocky coast is a pretty tough place if you're not used to it.

Here is a tidal pool. Just like its name, its a pool that gets bigger with high tide and smaller with low tide. High tide brings in cool, clean seawater with lots of oxygen and

What else is there to eat in a tidal pool? (1) seaweed.

small plants and animals called plankton for the tidal pool animals to eat. When it's low tide, some tidal pools dry up or become very salty as the sun dries up the water.

Hey, come and meet my friends the GOBIES who live in tidal pools and hang on to the rocks when the waves get big by using their fins to form suction cups.

High tide is a dangerous time for you to visit us. Wait for low tide when it is safe.

Have you wondered what happens to my friends when the tide goes down and water evaporates from the tidal pools? BLENNUS or ROCK SKIPPERS do just that . . . jump from pool to pool. Slow moving animals like OPIHI, PIPIPI, and PERIWINKLES or PUPUS attach themselves very tightly to the rocks to hold the water inside until the tides come in again.

D. Conservation

What is meant when the word CONSERVATION is applied to our seashore? It means the careful use of our shoreline resources. It means obeying rules established 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 posters below, which posters best show things you can do to help. Write A or B in the boxes below each set.

E. Limu

Many kinds of limu (algae or seaweed) found in Hawaii were used by the ancient Hawaiians as part of their diet. Almost every seaweed that could be eaten was gathered by Hawaiians.

Limu have holdfasts that help them stay attached to the bottom. The holdfasts don't absorb nutrients like roots of land plants do from the soil. Limu usually attach themselves to rocks rather than sand.

Algae commonly gathered by the Hawaiians for eating include: ASPARAGOPSIS (Limu kohu), DICTYOTA (Limu lipoa), ENTEROMORPHA (Limu eleele), HYPNEA (Limu huna), and GRACILARIA (Limu manauea). Others we commonly find on the beaches include: CODIUM, SARGASSUM (Limu kala) and ulva (commonly called sea lettuce).

F. Sandy Beach

Hi! I'm Sandy SAND CRAB and like all crabs I'm a crustacean. We crustaceans wear our bones on the outside. I dig backwards into the sand where the waves come and go to make my home. Come and meet some of my neighbors.

Green Sea Turtles no longer lay their eggs on the major islands. Do you know why?

Sh-h-h, here deep in the sand are Tammy turtle's eggs. Tammy is a GREEN SEA TURTLE who uses the sandy beach as a nursery. One night when she was ready to lay her eggs she got out of the water and climbed high up on the beach to find a "just-right" place for her nursery. Then she used her back flippers to dig a hole big enough for all her eggs. Did you know green sea turtles lay from 65 to 150 eggs at one time? WOW!

There's Cornelius, the SEA CUCUMBER. He looks like a vegetable but he is an animal. During the day he stays buried under the sand. At night he crawls out to look for food.

How do the shape of Auger Shells and Cone Shells help them move about under the sand? What would happen if they had shells shaped like a box?

Near Cornelius are AUGER SHELLS. These shells plow through the sand to look for food. Augers also use the sand to hide from the CONE SHELLS which eat other shells. Cone shells have a poison dart that comes out from the pointed end of their shell to sting their prey.

If you must pick them up, handle them carefully by the flat end.

Many other animals camouflage themselves. Why would an animal need to do this? (1) hide from predators and (2) hide from prey. Can you name some other animals on the sandy beach who use camouflage? (1) goby - rock colored, (2) sand crab and oama - both sand colored.

Hey, there's Flappy FLATFISH and Lizzy LIZARDFISH. They love to play hide-and-seek on the sandy bottom. They can change the color of their bodies to the same color as the sand. This is called camouflage. Sometimes they bury themselves in the sand so only their eyes are showing.

Hannah HINALEA also known as Wanda WRASSE uses the sand too. At night she goes into the sand to sleep.

Every summer this neighborhood is overrun by hundreds of OAMA. Oama are baby weke or goatfish. They are called goatfish because they have feelers called barbels under their chin which they use to find tiny crabs on the sandy bottom which they feed on.

G. Beach Plants

1. Land plants

Ko'a (*Acacia koa*): Ko'a is a fairly common native tree found throughout Hawaii at middle elevations. Its wood was valued by Hawaiians for many things including surfboards and canoes. Ko'a is in the legume family and is therefore related to peas, kiawe, sleeping grass and monkeypod. The outstanding characteristic of ko'a is the curved "leaves" (the true leaves are tiny opposing leaves) which can be seen from a short distance.

Ko'ali (morning-glory): Ko'ali is the common morning-glory found in many inland areas as well as near the shoreline. It is a vine with heart-shaped leaves and purplish flowers that bloom in the morning. Interestingly, ko'ali is related to the sweet potato; ko'ali is also directly related to po-hue-hue, the beach morning-glory and kaunaoa, a native dodder.

Mountain naupaka: There are several species of the genus Scaevola which are found in upland areas; all are directly related to the beach naupaka, naupaka-kai. Although the upland and coastal naupaka differs somewhat in appearance, the flowers are all similar in that all are "half-flowers." One legend has it that the half-flowers represent two lovers who were forced to separate; one was sent to the mountains--the other to the coast. To this day, the two lovers have not united.

2. Coastal plants

Manienie, *Cynodon dactylon*, is the most common lawn grass near the seashore. It has an amazing tolerance for seawater and will survive even after being covered with seawater. It is a small, low wide-creeping grass with narrow, straight leaves. It grows much like a weed and loves the sun, not the shade.

Pickleweed (akulikuli-kai, *Batis maritima*): Akulikuli is the Hawaiian word for "succulent." Its leaves are full of salt and at one time it grew in salt marshes in Honolulu. Akulikuli once covered much of Sand Island so that the island was once called Akulikuli Island.

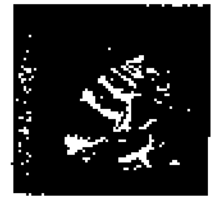
Beach naupaka (naupaka-kai, *Scaevola taccada*): Naupaka is a succulent shrub with fleshy leaves. It is one of the toughest plants in the coastal zone and can withstand salt spray, drought and heat. It is good for binding soil and will even grow on lava. The leaves can be cooked for greens.

Beach morning-glory (pohuehue, *Ipomoea pescaprae*): Morning-glory is found just above the high-water mark on beaches. It has smooth, thick leaves and a pink bell-shaped flower; most of the flowers bloom in the morning. The Hawaiians used to whip the water with the vines when they wanted high waves to surf on and they also used these vines to scare fish into nets.

Jacquemontia (pa'u-o-hi'iaka, *Jacquemontia sandwicensis*): This is a low-growing vine commonly found along the beach. It does well in clayish soils, especially on the leeward side of the islands. It's endemic to Hawaii and its name means Hi'iaka's shirt. Hawaiian legend says that the vine covered Pele's baby sister Hi'iaka to protect her from the sun when Pele left Hi'iaka on the beach to go fishing.

Ahinahina, *Heliotropium anomalum* is a low-growing succulent with clusters of tiny white flowers and leaves growing in rosettes. Ahinahina means "gray-gray," referring to the grayish silvery appearance of the leaves because of fine "hairs." These "hairs" reflect sunlight and protects the plant from the sun's extreme heat. The Hawaiians used the same name for another plant, the silversword, which also has a similar hairy appearance.

O'hai, *Sesbania tomentosa* is another coastal plant found in limited areas of the islands. O'hai can be readily recognized by its opposite leaves, salmon-colored flower with a "nose" like the pea flower, and long bean pods. O'hai is in the legume or pea family--and is related to plants such as monkey-pod, ko'a, kiawe, koa-haole and kalamungai, a small tree which is popular with local Filipinos for its leaves and beans. Like many other coastal plants, o'hai is well adapted for bright sun, heat and low rainfall with the surfaces on the leaves and branches covered with "hair."



II. THE OCEANS MOVEMENTS

Kersplash! The waves are big today and the surfers are out on our northern shores.

What makes big waves about 100 feet high?

What happens when they reach the shoreline?

In Hawaii there are two high tides and two low tides every day.

Do you know why there are tides?

Why do some places have only one high and one low tide? Why is the tidal range only three feet in Hawaii and 50 feet in the Bay of Fundy?

A. Where Do Waves Come From?

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 tradewinds. Since the tradewinds blow from the north, the best surfing spots are on our North shores.~~

Waves start out as the wind blowing across the water forms little ripples. These ripples get bigger as the wind blows harder. The longer the wind blows and the stronger the wind is, the bigger the waves. After a while when the wind dies donw, the waves do not stop. The energy will travel across the ocean till it reaches the shore. Storms at sea can send waves as high as 20 feet to Hawaii.

Storm surf even four to five feet high are dangerous for inexperienced surfers. At an unfamiliar beach, ask a lifeguard about bottom conditions and hazards even though the waters may look calm.

When the waves are breaking on the shore, don't go too near the water's edge. A big wave might come and sweep you into the water.

<u>Don't turn your back to the waves.</u>

Waves made from the energy given off when the sea floor moves are the biggest waves of all up to 100 feet. These waves are called TSUNAMIS.

B. What Is A Wave?

The lowest part of the 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.

C. Why Would You Not Paddle Out Too Far To Catch A Wave?

The water itself in the open ocean does not move forward only the energy of the waves moves. If the water does not move towards shore it will not take the surfboard in with it.

What is happening to the surfer who paddled out too far? Will he be able to catch a wave out there? Where would be the best place for him to be?

D. What Makes The Waves Break On Shore?

Not all of the wave is above the surface. The wave energy goes down the crest to the trough. When the wave touches the sea bottom it starts to drag and forces the water to pile up until the face becomes so steep that it spills over or breaks.

E. What Happens To All The Water The Waves Bring To Shore?

When the surf is breaking over the reef the waves drive the water toward the shore. All this water is now trapped between the shore and reef. When the water finds a break in the reef (channel) there is a rush of water flowing out to sea. This is a RIP CURRENT.

If you are caught in one don't fight it. Swim parallel to the shore up onto the reef and let the waves help you back in.

F. How Do Waves Affect Us?

In Hawaii we use waves to go surfing or body surfing.

We should be careful when riding waves. Hidden rocks may hurt us. Collisions with other people may hurt them or us. Getting caught in strong currents can carry us out to sea. Before entering the water, be sure you know the area, ask the lifeguard. Don't go into the water if the waves are too big or if you are tired.

Waves can make the beach a dangerous place to be.

While fishing or picking opihi from a craggy coast or picking shells on a sandy beach with large waves, don't turn your back to the waves. Extra large waves often come in and reach high up on the beach.

When sailing out through the breakers know your boat and what to do if the waves are bigger than you though.

Look at what happened further down the coastline to this beach.

Waves can change a whole coastline by erosion.

Engineers have tried to save beaches and coastal areas from erosion by building breakwaters and jetties.

Tsunamis can destroy a whole coastal town.

G. Our Tsunami Warning System

Tsunami waves are the most destructive waves known. One of the greatest tsunamis known was caused in 1883 by the explosion of Krakatoa, a small island off Java and Sumatra (Indonesia). More than 36,000 persons were killed and waves in some areas were as high as 35m ft.

Commander C.K. Green of the Coast and Geodetic Survey developed an instrument to warn of approaching tsunamis. An alarm goes off at instrument stations around the Pacific and the information is forwarded to Honolulu, the center of the warning system.

The determination of the epicenter or point of origin of an earthquake that can cause tsunami helps to estimate when the tsunami waves will reach Hawaii. Since shock waves of earthquakes travel faster through the earth than through water, earthquake watch stations are able to warn within minutes coastal residents to evacuate their homes if large waves are expected.

The warning is the Civil Defense "Attention/Alert Signal" which is a steady siren tone for one minute followed by one minute of silence.

If there is an earthquake here in the Hawaiian Islands that causes you to fall or makes you hold on to something to keep your from falling this should be a natural tsunami warning. Get to higher ground right away if you are near the seashore.

H. What Are Tsunamis?

Commonly called "tidal waves," tsunamis (tsu-NAH-mee) or seismic waves have nothing to do with tides. Tsunamis are giant waves made when the sea floor moves because of earthquakes, landslides or volcanic eruptions. Most tsunamis happen in the Pacific Ocean because of all the volcanic activity happening around and in it. Earthquakes commonly occur near deep trenches and the Pacific has a ring of such trenches. Tsunamis are not just a single wave; they are a series of waves separated by 15 to 60 or more minutes. Ships at sea sometimes do not know when a tsunami swell is passing because they are only a foot or two high. However, as the tsunami nears shore it turns into 12 to over 30 m waves. Usually, the third to the eighth waves are the biggest. The waves can travel over 500 miles per hour in the open sea. Over the past 150 years, the Hawaiian islands have had an average of one tsunami every four years.

I. What Makes The Tides Higher In Some Places Than Others?

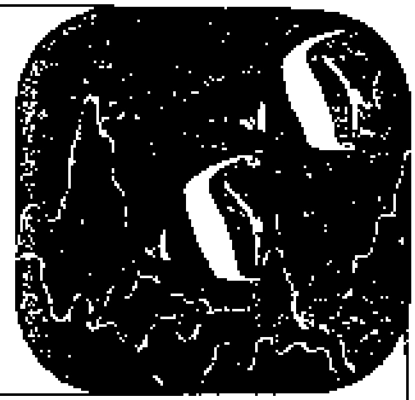
The pull of the sun and moon is not even all over the world at the same time. This is because the ocean bed is divided into many basins. Each of these basins acts like a separate body of water. Each basin has its own particular rhythm. At the edges of the basins the tides are the greatest and in the center, the smallest. The things that influence the tides are the depth of the water and shape of the coastline.

The greatest tides occur where water is found through a narrow opening, such as a long narrow bay. In Hawaii, the greatest difference between high and low tide is about one meter. The Adriatic Sea also ranges about one meter, but in parts of the English Channel the tidal range is about 9 m. The highest tides occur in the Bay of Fundy in eastern Canada. A lot of water enters the mouth of the bay and quickly fills it up. The tidal range there is about 15 m. However, just outside the bay on the Atlantic Ocean, the tidal range is about 2 m.

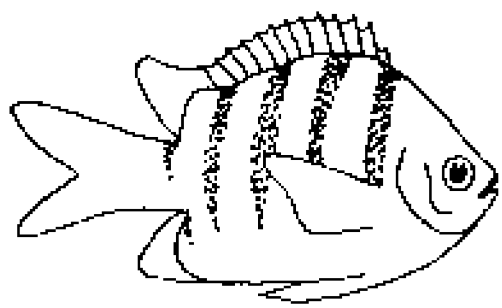
J. What Causes Tides?

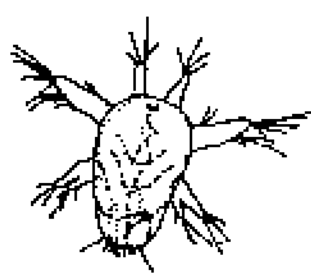
Tides are caused by the sun and moon's gravity playing "tug-of-war" on the earth. Even if the moon is smaller than the sun, it pulls harder on the earth because it is closer. Wherever the moon is, it pulls hardest on the part of the earth facing it. This causes the water on that part of the earth to bulge toward the moon. Directly on the opposite side of the earth the water bulges away from the moon because this is where the moon's pull is the weakest. This bulge follows the moon as the earth turns.

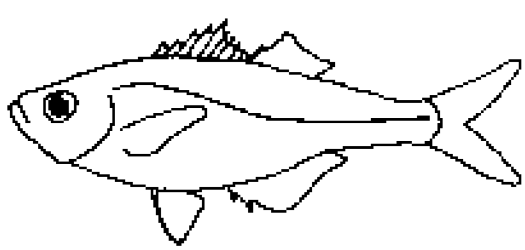
Twice a month the moon and sun are in a straight line with the earth. The pull of both combined will cause the bulge to be a little bigger. A bigger bulge means a higher tide which is called a SPRING TIDE. A NEAP TIDE or smaller than normal tide occurs when the moon and sun are pulling at right angles to each other.

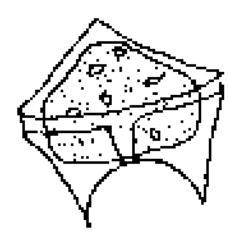


OUR HAWAIIAN REEF









I. REEF COMMUNITY

A. Reef Community

1. Life on the bottom

Many animals and plants live on the bottom of the ocean. We call them benthic dwellers. *Benthic* or *benthos* means bottom. Some of these animals and plants start out as plankton or drifters, then settle on the bottom to spend the rest of their lives. Corals and limu find a place that's right for them and permanently attach themselves to the bottom. Other animals that crawl, creep or even swim close to the bottom are also part of the benthic community.

What do all these animals and plants have in common? They all need to be near the sea floor to live. These benthic dwellers could not survive in open water.

Pictures of:
sea anemone
*limu
*coral
crabs
cowry
flying gurnard
flounder
sea cucumber
tako
hinalea
sea urchin
shells

Which of these benthic dwellers spend the rest of their lives in one spot?* How can you tell?

2. Swimmers

NEKTON are the swimmers of the sea. They are the animals that can move through the water on their own power.

There are many ways nektonic animals get around in the ocean.

Most fish use their bodies to push water in a side to side motion. Some fish like hinaleas use their pectoral fins to pull themselves along. Fish also use their fins to help them to turn, stop, dive or go up towards the surface. A fish can soar through the water like an airplane soars through the air. A hammerhead shark pushes himself through the water in a side to side motion of its body like other fish but he has a very special-shaped head that helps him to make turns, dive, and surface.

Mammals like whales, porpoises, and people use an up and down motion of their bodies to get through the water.

Squid and octopus use jet propulsion to get from place to place very fast. Unlike the octopus who spends most of his time on the sea floor, the free-swimming squid has a pair of large fins on each side of its body which it uses to turn, dive, and even hover.

3. Drifters

PLANKTON, unlike nektonic and benthic animals, are not able to go where they want to against the winds and ocean currents. A few plankton are large animals like the Portugese man-of-war and jellyfish that are very weak swimmers who have little or no control of where they are going.

However, most plankton are too small to be seen without a microscope. Some of them spend their whole life drifting while others are the young of benthic and nektonic dwellers. After a while these temporary plankton will fall into deeper water or settle on the ocean floor to grow up into forms we can recognize.

The whole Sargasso Sea is also planktonic. It is made up of floating sargassum, which is a type of floating seaweed that has tiny gas-filled balloons. All the animals that live in this mass of drifting seaweed are part of the planktonic community.

4. Game

Pass out cards with animals and plants and ask students to group themselves under correct area. Time each group and post time score.

BENTHOS

SEA URCHIN	COWRY
STARFISH	LIMU
FLOUNDER	CORAL
STONEFISH	SEA ANEMONE
EEL	STING RAY
TAKO	

NEKTON

TUNA	SQUID
DOLPHIN	BUTTERFLY FISH
UHU	MANTA RAY
ULUA	AHOLEHOLE
SHARK	MANINI
HAMMERHEAD	

PLANKTON

PORTUGESE MAN-OF-WAR	LARVAL SEA URCHIN
JELLYFISH	FISH EGG
SARGASSUM	COPEPOD
LARVAL CRAB	LARVAL SEA CUCUMBER

B. Hidden Dangers Of The Reef

Let's look at some of the things to be careful of when you explore the reef. What should you do to protect yourself?

1. Take a friend along, just in case.

2. When you are walking on the reef watch where you are going. The rocks in the water may be covered with slippery limu. There may also be deep holes in the reef flat. You'd be wise to wear shoes (like tennis shoes) or tabis and long pants.

3. Stony corals that reefs are made of are sharp. If you do get cut by coral, clean it out well. See a doctor right away if the cut does not heal nicely.

4. When you're walking or snorkeling on the reef, never turn your back to the ocean. Always keep an eye on the waves to see if they are getting bigger. Be sure you're not trapped out on a reef by the high tide.

5. Some animals may bite you to defend themselves. Squids and octopus have powerful parrot-like beaks that can hurt you. Eels have very sharp teeth and may bite if you stick your hand or foot in their hole. Learn to pick up crabs and lobsters correctly, not only do they have pinchers but sharp spines on their armor plates. If you leave most of these animals alone, including sharks, they will probably leave you alone.

6. Jellyfish and Portuguese man-of-war have nematocysts which are stinging cells on their tenetacles. Some cone shells have darts that are poisonous to people. If you have to handle them, pick them up only by the broad, flat end. The black long spined wana has poisonous spines that will go into your skin and break off. Do not handle them even with gloves.

7. Breakers carry large amounts of water over a coral reef or sand bar. The force of these waves traps the water between the reef or bar and the beach. If there is any break in the length of the reef, water will flow back to the ocean through this channel. Water coming from both directions inside the

reef creates a current going straight away from the beach. This is a RIP CURRENT.

What should the swimmer do? Which way should he swim?

Rip currents are strong and should be avoided. (Learn to spot rips. They usually hold back waves and are sometimes discolored by sand or debris picked up off the bottom.) If you are ever caught in a rip current, swim parallel to shore. When you are out of the rip current, swim towards shore.

C. Reef Builders

Did you know that reefs were built by both animals and plants? Did you know that coral as large as you head takes 40 to 50 years to grow? Did you know that around Hawaii, most reef building corals are not found below 50 m (150 ft) deep?

Corals are skeletons of many tiny animals called polyps. Coral polyps live together and from the seawater draw calcium carbonate, the rock-like material that reefs are made of. A type of seaweed called coralline algae also draws calcium carbonate from the water and helps to build reefs by cementing together shells, sand and coral fragments.

In the United States, only two states have the right conditions for coral reefs. They are Florida and Hawaii. Reef building corals need water temperature above 21°C (70°F) all year around in order to live.

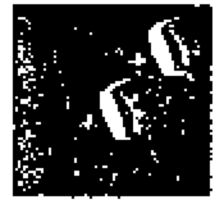
Different types of coral grow at different depths and under certain conditions. What happens when something upsets this delicate balance?

Besides the right temperature, stony corals also need clean and constantly moving sea water. This current brings in needed oxygen and plankton for coral polyps to eat. Stony corals also need sunlight because they have algae living inside their polyps. The polyps and algae help each other out to build the reef. For this reason, stony corals usually go not grow below 50 m (150 ft) deep. It is the different types of algae in different live corals that gives them color at night when the polyps bloom like flowers. Their "petals" are actually tentacles with stinging cells which they use to catch the plankton floating by.

1. Types of reefs and where they are found.

2. Precious Corals

Reef corals are different from precious corals which jewelry is made of. Stony reef corals form the rock-like reefs. Precious corals are soft corals or alcyonarians. They are not able to form the limestone skeletons like stony corals. Another difference is that stony corals need the algae in their bodies to live. Because algae need sunlight, stony coral can only live in depths that sunlight can reach. Precious corals do not have algae in their bodies, so they are able to survive in the dark depths and live in depths anywhere from 30 to 470 m (180 to 2820 ft). Black, pink, and gold coral are found around the Hawaiian Islands. The manufacture and sale of precious corals has earned many millions of dollars for the coral industry.



II. THE CHAIN OF LIFE

Some animals in the ocean eat PLANKTON which are tiny plants and animals that drift in the sunlit layers of the ocean. The tiny plants are called phytoplankton and the animals are called zooplankton. All life in the ocean depends on phytoplankton in some way. Small animals eat the zooplankton and bigger animals eat the smaller animals. The relationship of who eats what is called the FOOD WEB.

A. What are Plankton?

The word "plankton" means "drifter." Plankton are tiny plants and animals that drift in water. 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 drift in the currents.

Scientists divide the tiny plankton into two groups--phytoplankton and zooplankton. Phytoplankton are plants and zooplankton are animals. Phytoplankton are plants because they can use sunlight and minerals to grow just like land plants.

Plankton net construction instructions in teacher's guide sheet.

Scientists use a net that has very tiny holes to catch plankton. The net is dragged behind their boat. You can make your own net using old panty hose and some stiff wire. You will need a microscope or magnifying glass to see what you've caught.

1. Phytoplankton

Phytoplankton are tiny marine plants. You know that limu (or seaweed) are also ocean plants but phytoplankton does not grow attached to the bottom like limu. They spend their whole life floating near the surface of the ocean.

Land Plants and Marine Plants

Type	Sunlight	Minerals	Temperature
Marine Plants	produce energy through photo-synthesis	from sea water	moderate - not too warm nor too cold
Land Plants	produce energy through photo-synthesis	from soil	moderate - not too warm nor too cold

2. Zooplankton

Zooplankton are tiny animals that drift in the ocean currents like the phytoplankton. Some zooplankton float for their entire life in the ocean. These PERMANENT ZOOPLANKTON do not change their body shapes. Other zooplankton are called TEMPORARY ZOOPLANKTON because they spend only part of their life as plankton. 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.

The most abundant kinds of permanent zooplankton are probably copepods. There are over 10,000 species of copepods in the waters on earth. Can you imagine how many that is? The copepods are crustacea and have long antennae like lobsters. These antannae are covered with feathery bristles that help the copepod to float in the water. There are male and female copepods and they reporduce by sexual mating.

3. My Junior, how you've grown!

Remember the zooplankton that spend only part of their life drifting? They are the eggs or larvae of animals like starfish, crabs, sea cucumbers, sea urchins, and many others. See if you can match the babies with the adult animals.

B. Food Chain and Pyramid

Ever stopped to think what the beginning of all life is in the ocean? Where does food come from? All life depends on some other living thing for food, be it animal or plant material. The food source chain in the ocean starts with phytoplankton. Phytoplankton are called "primary producers" because they need only the sunlight and minerals to grow. Phytoplankton do not eat other living things.

In the ocean, the "chain of life" is very easy to see. It begins with zooplankton eating phytoplankton; the zooplankton in turn are eaten by small fish which are eaten by larger fish which are eaten by even larger fish.

Another way of looking at the "chain of life" is as a food pyramid. How much weight do you suppose you would gain if you ate 10 kg of food? No, not 10 kg, but about 1 kg. Marine animals gain weight in the same way. It takes 10,000 kg of phytoplankton to produce 1,000 kg of zooplankton which will in turn produce 100 kg of small fish and so on.

C. What are Food Webs?

Food webs show the relationship of which animals eat which plants and/or other animals. Plants depend on sunlight for their food. Animals eat plants so the animals depend on plants.

In order for you to survive, you must eat enough food and drink enough liquid. The animals in the ocean are just like you; they need food to live. Suppose you grew your own food, if all of a sudden there was a large population of worms in your garden that ate most of your vegetables, you would not have enough food to eat.

The same idea is true for food webs in the ocean. A large increase or decrease in the number of an animal or plant can harm the food web's balance. Changes can cause damage for years in the future.

Example of balance:

--Sea urchins and kelp
Sea urchins chew off kelp holdfasts

Beds of California coast were being destroyed because urchins caused the mature plants to float away and no new spores were able to settle and produce new plants. The sea urchin population increased because the population of sea otters that feed on sea urchins was decreasing because sea otters were being hunted for their fur.

1. Diagram of a reef food web.

This is an example of a reef food web. Notice how the animals and plants relate to each other. What do you think would happen to the reef if a sewage outfall was placed nearby? Sewage is a NUTRIENT or fertilizer. Extra nutrients in the ocean means an increase in the amount of plants or phytoplankton. How would the extra nutrients change the reefs? What happens when rain washes loose dirt from homes being built near the shoreline? How does this affect the food web?

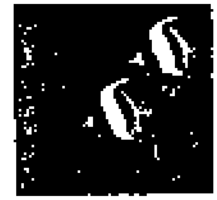
2. How are food webs affected by their surroundings?

People often cause problems in food webs by throwing them out of balance. This is known as "STRESS." Your activities on land and in the sea affect the delicate balance of food webs.

Suppose people around the world caught a lot of fish of one kind. The species would become extinct because too many of them have been killed. This is happening today with certain species of whales. To protect them from being totally wiped out, an international agreement prohibits the killing of these whales. What would happen if the whales became extinct? How would this affect the population and balance of some of the things whales feed upon?

Oil spills, run-off of mud and dumping of wastes into the ocean can harm the animals of a living reef. Oil coats feathers on birds so they can't fly. Mud from land settles over the algae and coral and kills them. Sewage wastes can cause an overproduction of life which also upsets the balance of food webs.

You can help to keep food webs in balance. Think carefully before you do things that can harm the animals that live in the ocean.



III. ADAPTATION

All of the animals who live in or near the Hawaiian reefs have developed in some way to fit into this complex community. On the reef each has found a place and a way to survive. Some animals use speed to get away from predators while others camouflage themselves. Coats of armor and special stinging cells protect those that can not get away. Some animals have also developed special relationships with others. One member of the reef community, the shark, has been singled out to show how it has adapted in form and habit to the environment. The shark is one of the best adapted members of the reef community.

A. Methods of Feeding

Animals in the sea are HERBIVORES or plant-eaters, CARNIVORES, or meat eaters, or OMNIVORES, plant and meat-eaters. Each species has developed specialized methods of obtaining food.

Sand dollars and sea urchins have a radula which are teeth that were discovered by Aristotle in the 4th Century B.C. He described them as looking like a horn lantern with the panes of horn left out so the radula have been called "Aristotle's lantern" ever since then.

Sea urchins and sand dollars have RADULA, a circle-shaped mouth with five teeth that enables them to gnaw on seaweed and other small animals.

Some fish are carnivorous. They have sharp, pointed teeth that catch and hold their food before they swallow it. The fish don't use their teeth to chew their food; they swallow their food whole or cut it into bite-size chunks. Fish have PHARYNGEAL TEETH or teeth that are far down in their throats so the fish can chew and still pass a current of water over their gills.

Some fish like nehu and whale wharks are plankton feeders. They have GILL RAKERS that are simple or branched tooth-like projections arranged in rows like a comb that catch the plankton. The spacing and structure determine the general size and type of plankton that the fish eat.

Whales are divided into two general categories: toothed whales like the sperm whale and baleen whales like the humpback or great blue whale. Instead of teeth baleen whales have bristles with which they strain out tiny krill from the water. The baleen whale takes in large amounts of water into its mouth and forces the water out through the bristles with its tongue. The small organisms caught in the bristles are swept into the throat with its tongue.

Some animals like the sea anemone, Portuguese man-of-war, and jellyfish use STINGING CELLS to stun their prey. When the prey are stunned, the predators can easily eat it.

Some animals like the starfish, squid, and octopus use their "ARMS" and SUCTION CUPS to snare their food or pry open shells. Starfish can pull apart oyster shells to eat the animal inside.

B. Sharks

Of all the animals in the ocean, it is the shark that has the perfect form for living in the water. Sharks are so well adapted to their watery world that they exist today in nearly the same form as their prehistoric ancestor, *Carcharodon megalodon*. Because sharks do not have any bones, the only remains are fossil teeth. Imagine how big the *C. megalodon* must have been! Look at the size of its tooth compared with a tooth of the great white shark.

1. Pelagic or oceanic species of sharks have streamlined, TORPEDO-SHAPED BODIES that allow them to swim great distances. Some bottom-dwelling sharks have adapted and are flat-bellied.

2. Like other surface fish, most sharks are COUNTER-SHADED, which means they are dark colored on top and light underneath. Sharks that live on the sea floor, like the Australian wobbegong or carpet shark, *Orectolobus barbatus*, blend in with the sea floor and are CAMOUFLAGED.

3. Sharks do not have scales. They have tough skin called SHAGREEN which is covered with denticles. DENTICLES are primitive placoid scales that are about the size of a grain of sand. That is why shark skin feels like sandpaper. Also, see number 12.

4. The pectoral or side and dorsal or top fins act like STABILIZERS of an airplane. These fins help the shark to dive, turn or go up to the surface. However, these fins can't help the shark to "brake" so it uses these fins to veer off instead. The diagram shows how the cross-section of a shark's fin looks just like an airplane wing.

   The hammerhead shark has a specially shaped head that is an extra maneuvering "wing" or fin.

5. Sharks have GILL SLITS in the skin and not a bony plate like other fish.

6. Sharks jaws are full of many rows of teeth. These teeth are the same as the denticles found on the shark's skin. The denticles in the mouth serve as teeth. These "teeth" are not attached to the jawbone like bony fish, but grow in its skin. The teeth move outward and get bigger until their roots emerge from the skin. Worn teeth fall out. Some sharks like shellfish, have molar-like teeth instead of sharp wedge-shaped teeth.

More ways sharks have adapted:

A. Sharks have not developed an air bladder like bony fish. For this reason they must keep moving to keep from sinking to the bottom.

B. Sharks have short but very efficient intestines with a spiral structure inside.

C. The main difference between sharks and bony fish like the ulua is that sharks do not have bony skeleton. They use the water to support them.

D. Jaws open very wide and as muscles tighten it moves the teeth outward so they are able to get a good grip. The jaws of a shark are so strong that an eight-foot shark can exert a pressure of 3 metric tons per square inch when it clamps down.

7. One of the best sense devices the shark has is the SENSORIAL CANALS which are located along the LATERAL LINE of the shark. Like radar, the canals can pick up vibrations and pressure waves, especially those of a wounded fish.

8. The nostrils of a shark are covered by SCHNEIDERIAN FOLDS which create a canal through which water flows. The nostrils are placed far apart to locate prey more accurately.

   Sharks also have LORENZINI FLASKS to help them sense differences in pressure.

   The shark's skin has SENSORIAL CRYPTS which it uses to "taste" the water for what is around.

C. Symbiosis

Gosh, that looks like a hard word! What does it mean? It means, very simply, *to live, together*. Plants may live with plants; animals may live with other animals; or plants and animals may live together. Symbiosis usually involves two organisms, be they plants or animals.

There are three kinds of symbiosis:

1) Both organisms help each other out. They give things to each other and don't harm each other.

2) One of the animals will help the other but the one that is helped does not help its helper.

3) One organism harms the other it lives with.

1. What are some examples of symbiosis?

1. GALL CRAB (*Hapalocarcinus marsupialis*) in CORAL (*Pocillopora damicornis*). The female gall crab lives in a pocket in the coral. She somehow shapes the coral growth around her and cannot leave once the coral surrounds her. She is protected from her enemies by being surrounded by the coral.

2. RED HERMIT CRAB (*Dardanus gemmatus*) and SEA ANEMONES (*Calliactis armillatus*). This particular hermit crab can actually remove a sea anemone from the rocks and put the anemone on its shell. The anemone's stinging cells protect the crab from its enemies like the octopus. The anemone cannot move by itself; by riding on the crab's shell it can now move from place to place.

3. CLEANER WRASSE (*Labroides phthirophagus*). This fish is found nowhere in the workd but in Hawaii. It helps other fish by cleaning off their parasites (tiny germs); the fish are healthy and the wrasse gets food by eating the parasites.

4. SEA ANEMONE (genus *Stoichactis*) and CLOWN FISH (*Amphiprion bicinctus*). The clown fish hides in the sea anemone in time of danger. The fish usually live in pairs with the anemone. This particular anemone is not found in Hawaii; it was brought to the Waikiki Aquarium from Canton Island.

D. Shaped for Living in Water!

Next time you're at the beach, wade up to your waist and try running through the water. If you've done this before, you know how hard it is to move forward. The animals in the sea must adapt to moving about in water.

Fish have different shapes to help them live in the water. Some, like tunas, are shaped like TORPEDOS and this allows them to move quickly through the water. Another is the elongated shape which makes the fish, like barracudas or opelu, look like a CIGAR. This shape also helps in quick movement because the body is streamlined.

Fish like the flounder live on the bottom and are FLAT. Other flat animals are skates and rays which also live on the sea floor. Some fish, like butterfly fish, are very THIN and when you look at them from the front there's hardly anything there. This helps to protect the fish and helps it move through the water with less friction.

There are fish like the puffers and stonefish which are not sleek or streamlined. They are NEARLY ROUND. These fishes do not have to be speedy or travel far to exist.

Now let's think about the animals that hide in holes. Eels are FLEXIBLE and long and skinny. They can easily fit into the crevices in the rocks. Brittle stars are also quite flexible and can crawl into very narrow cracks. Octopus have soft bodies and can slip into tiny holes.

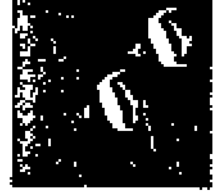
E. Movement in Water

How does a fish move? It moves by PUSHING WATER TO THE RIGHT AND THEN TO THE LEFT WITH ITS BODY IN A SIDE TO SIDE MOTION. Porpoises use the same motion but theirs is up and down. Some fish are so streamlined that they have grooves on their bodies into which their fins fit.

People thought, for a long time, that the tail fin was the most important one for swimming. In an experiment, two identical fish were put in a tank and the tail fin cut off from one of the fish. Both fish could swim at the same speed when frightened. It's the muscular action of the body that makes the fish move forward. The other uses of fins are, to help a fish keep upright, to turn, or to stop. Some exceptions to using the muscular action of the body in swimming are the hinalea or wrasse and the seahorse. The hinalea uses its pectoral (side) fins to pull its body through the water and seahorses use the dorsal fin on their backs to move about.

Manta rays have developed large pectoral fins. These are the fins that look like wings which the manta flaps to soar through the water.

Some animals move by JET PROPULSION. For example the octopus usually crawls along on its suctioned arms but if it's frightened it can eject water from its mantle cavity through a siphon. As the water spurts forward, the animal moves backwards. Squids use jet propulsion too, but they have fins on the sides of their body which help to control their movement. Octopus just move in one direction but squids, which spend most of their time swimming about, go forward and backward and turn with the aid of their fins.



IV. PROTECTION

In the context of the sentence, what do you think "predators" means?

In the reef world, the "fastest jaw in the West" is the survivor. Those who are small or otherwise defenseless have found ways of protecting themselves from PREDATORS who are looking for food and people who may also be looking for a meal.

A. Camouflage

Camouflage is a widely used protection device. The animals try to hide themselves in their surroundings or they try to confuse their enemies. Camouflage comes in many forms--color, shape, and masking. The easiest way to understand this form of protection is to look at some examples.

1. Protective coloration

How do the marine animals get their colors? They have special cells in their skin called CHROMATOPHORES that contain the color pigments. The animal controls the size of the cell openings to produce different shades of color. Three kinds of pigment found frequently in fish are: (1) orange, yellow or red; (2) black, and (3) guanin which produces white, silver or irridescent hues. A combination of guanin and black produces the metallic blue and green colors. Fish, shrimp, squid, and octopus have chromatophores. These are cells on the body that can change the animals' color to match their surroundings.

Countershading is a special type of coloration. Fish are dark-colored on their backs and light on their bellies. When you look at the fish through the surface of the water, they blend in with the deep blue ocean water; when looking at the fish from below they blend in with the light.

2. Shape

The shape of some animals helps them to look just like their surroundings and makes it hard to tell if they are there. See if you can find the animals in this diagram.

3. Masking

Some crabs feel very uncomfortable without algae, sponges or anemones on their backs. Scientists have done experiments where they have removed sponges from the crab. The crab immediately looks for more sponges to cover itself with. When the masked crab stops moving, it just disappears into its surroundings.

4. Mimicry

Other methods of protection. Marine animals have ways of protecting themselves that are not so obvious.

B. Schooling

Certain fish SCHOOL or swim together in large groups as a means of protection. Schools are made up of the same type of fish that are all about the same size. When there are many fish together and none of the fish stand out as being extra big or little, the predator is confused as to which one to attack. There is safety in numbers. Also, a tightly packed school of fish looks like a single large, dark moving mass and this may frighten off predators.

C. Ink Cloud

Squid, "ika," or octopus, "tako," are able to shoot a dark ink cloud that hides their escape. It is not till this cloud clears that the predator can start looking for its victim. After the octopus, which usually crawls about the sea floor, ejects its ink and uses jet propulsion like the squid to make a fast getaway.

The deep water relatives of the squid and octopus that live in total darkness do just the opposite. Instead of a dark cloud which would not show in the darkness, they eject a bright glowing cloud which works in the same way.

D. Teeth and Jaws

Sharks and barracudas are famous for their sharp teeth. Shark and barracuda teeth are very different. Sharks feed on large prey. They have teeth that can clamp down on and with a side to side motion of their heads "saw" off chunks out of their prey. Their razor-like triangular teeth leave ragged-edged wounds.

Barracudas eat smaller fish. They have needle-sharp teeth which they use to grasp and hold small fish before cutting it into bite-size chunks.

E. Caves or Holes

Most of the animals that live in caves and holes come out to feed at night when they can't be seen by their enemies. Lobsters and morays have a neat relationship. A lobster will share a cave with a moray eel who will protect it from octopus (and an occasional diver).

The Alpheus shrimp lives in a hole in the sand. It will retreat into the hole when danger threatens.

Triggerfish and file fish have a double dorsal spine, one of which is used to wedge itself tightly in cracks in the reef. The second dorsal spine acts as a locking trigger.

F. Regeneration

Can you name one animal on land that can grow back a part of itself?

Some animals in the ocean are able to grow new parts to replace old ones that they've lost. A starfish can grow back an arm it lost in a struggle. If that lost arm has part of the body disk attached a new starfish will grow from that part. The starfish, *Linckia*, can grow a whole starfish from even very small pieces.

Sea cucumbers will eject parts of their intestines when they are threatened. This distracts the predator enough for them to make a getaway. They can grow back any part they need.

A "tako" can grow back an arm that is lost when trying to escape from a moray eel.

Crabs and lobsters are able to drop their claws and antenna to escape from "takos" and other predators. These are replaced when they MOLT. Molting is the process crustaceans like crabs and lobsters go through when they grow too big for the crust they are wearing and shed it for a new and larger one growing underneath.

G. Reproduction

Reproduction is a method of protection because it is a way to make sure that the species of animal will be here in the future.

Some fish lay many, many eggs to make sure that a few will survive to become adults and breed. A 22.9-cm (9 inch) opelu, *Decapterus pinnulatus*, has an average of 82,000 eggs in its ovary. These eggs are not looked after by the adults, but drift as plankton. Many are eaten or die, but a few will survive.

Seahorses also have many eggs but the male seahorse will carry the babies in a pouch until they are ready to be on their own.

H. Hard Outer Coverings

Some animals have hard outer coverings to protect themselves. The coverings can be shells, rough skins, scales, or even protective plates. These coverings are just like a suit of armor.

Oysters and clams have hard shells. They can close their two shells together so their enemies have a hard time eating them. Opihi only have one shell but they have a strong muscle that helps them cling to rocks with the shell to protect them. Cowries can hide in their shells.

Fish scales help protect them from rocks and coral. If you were wearing long pants and a long sleeve shirt when you fell on some rocks, you probably wouldn't get cut as much as if you were wearing shorts. Fish scales help the fish in the same way.

A really neat outer covering is found on chitons. Chitons have soft bodies and on the outside they have eight overlapping plates to protect themselves.

Crown of thorns starfish and other starfish have tough skins. So do sharks! Shark skin has little "teeth-like" scales, each about the size of a grain of sand. Shark skin was once used as sandpaper, so you can imagine how it feels!

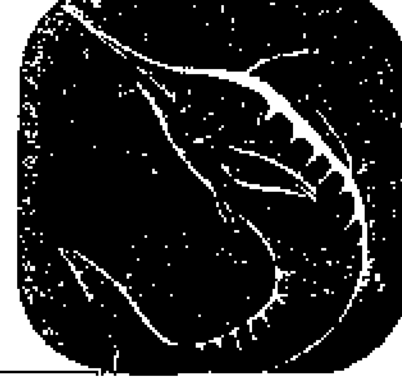
Crabs and lobsters have their "bones" on the outside. These "bones" cover their soft bodies and protect them from harm. When you see one along the reef, try toughing its shell. You'll see that it is pretty hard.

Spines are those sharp, pokie things on fish and sea urchins. Because they poke, they serve as a protective device. Some fish and sea urchins have poisonous spines that can make you very sick.

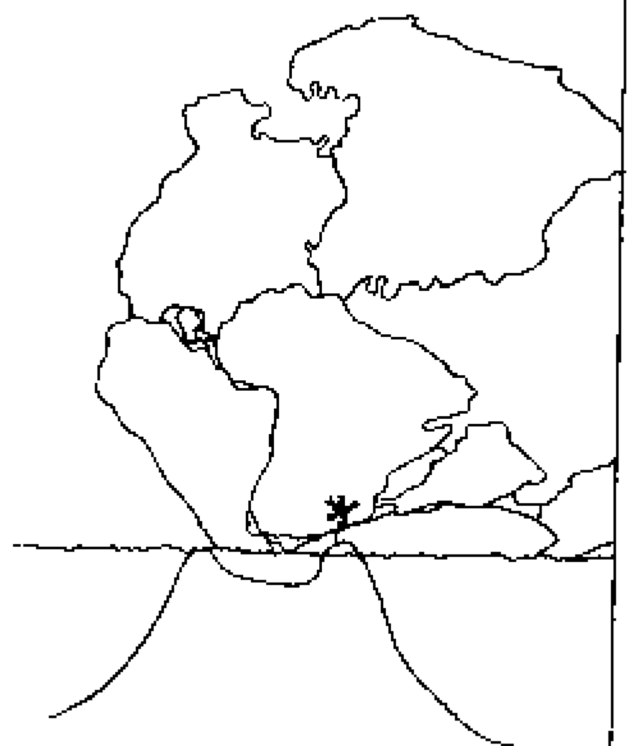
Let's look at some examples of protective coverings.

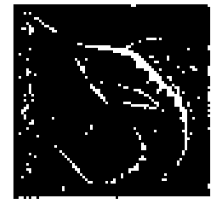
I. Stinging Mechanisms

Animals of the phyllus Cnidaria (or Coelenterata) have stinging cells which they can use to protect themselves. These animals include sea anemones, fire corals, jellyfish, and the Portuguese man-of-war. Lionfish (*Pterois sphex*) have long spines that can inject a poison. Cone shells have a dart-like mechanism that can sting you if you pick them up by the narrow end.



DEEP BLUE WATERS





I. THE OCEANS

The ocean floor, a short distance from shore, off any Hawaiian island, may plunge down to depths of more than 180 m (about 600 ft) into what can be called "deep blue waters." Light does not reach down much below 185 m. Great submarine river systems circle the world and the movement of the water circulates food to the ocean's plants and animals.

The ocean floor, hidden under the deep blue waters, has deeper canyons and higher mountains than any found on land.

A. What Makes Water Move?

When you go to the beach, you must have noticed that the water never stops moving. Have you wondered what makes the water move?

Winds, tides, temperature changes, and the rotation of the earth help move the oceans. If the water stopped moving, animals and plants would die. The moving water carries food and oxygen to marine organisms.

B. Ocean Currents

An ocean current is water that moves in a certain direction like a river. Oceanographers have found that there are SURFACE CURRENTS (those on top of the water) and DEEP CURRENTS that flow underneath the surface. You may think that the waters would get mixed up but they don't. Different water temperatures and different degrees of saltiness keep them separate. Ocean currents flow about as fast as you can walk.

Some currents last only a little while and cover only a small area. These currents may be caused by tides and storms.

1. How do ocean currents affect you?

Currents that surround Hawaii bring warm waters to the islands. Scientists have found that the temperature of the water affects CLIMATE. When warm wind blows across the ocean, the water absorbs the warmth from the air which can help to keep you warm.

Another way currents affect you, is by causing UPWELLINGS. Upwellings occur when the cold bottom water rises to the surface near land masses. Along the western coasts of the continents, the surface water moves away from the shore because of the wind action. Since the surface water is pushed away, deeper water comes up to replace it. (Diagram)

This deep water contains a large supply of NUTRIENTS. Nutrients are minerals that phytoplankton need to grow. This creates great fields of phytoplankton and results in large numbers of fish in those waters. Upwelling is good for fishing but not for swimming since the deep water is colder than the surface water. Upwellings may bring water from 200 to 300 m deep to the surface and upwelled water may extend to 100 km off shore.

C. Minerals in the Ocean

MINERALS in the ocean are found on beaches, in seawater, and on the sea floor. Especially important to Hawaii, are manganese nodules found in the waters surrounding the islands.

Gold, diamonds, platinum, silica and magnetite are some important minerals mined from beaches. Off the coast of Africa, tons of diamonds are mined.

Seawater has almost all the known ELEMENTS dissolved in it. Only four elements are commercially extracted--sodium and chlorine which make up salt, magnesium plus some of its compounds and bromine. Salt is part of your diet; bromine is used a lot in photography. Obtaining freshwater from salt water called DESALINATION is mainly done by an evaporation process. In some areas, desalination provides a much needed source of freshwater.

Companies now drill the sea floor for oil using offshore, large derricks. Coal and iron ore are mined in areas offshore of England, Japan, Newfoundland and Finland. Exploration of the deep sea floor for mining has just begun. It is estimated that about 140 billion metric tons (1.5 trillion tons) of manganese nodules are on the floor of the Pacific Ocean. Some scientists think manganese nodules are accumulating at the rate of 9.1 million metric tons (10 million tons) per year.

1. What are manganese nodules?

MANGANESE NODULES or FERROMANGANESE NODULES are small rounded lumps of minerals found on the bottom of the ocean. Important elements found in the nodules are manganese, cobalt, copper, and nickel. Ferromanganese nodules are found around the world. The largest concentrations are found in the north Pacific. Not all of the nodules contain valuable metals. Widespread and rich deposits of ferromanganese nodules are found about 80.6 km (500 miles) south of Hawaii.

Right within the Hawaiian Archipelago deposits are found mainly on three terrace levels around the islands--400 to 800 m, 1,200 to 1,600 m, and 2,400 m.

D. What is Happening to the Sea Floor?

Although you cannot see it, the OCEAN FLOOR is actually moving. Oceanographers have found that the ocean floors are SPREADING apart at the underwater ridges or mountain ranges. The spreading rate is between 1 and 5 cm per year. If only spreading occurred, the earth will get bigger each year. However, you need not worry about the earth blowing up because there are areas where the ocean floor folds back into the center of the earth. This occurs in the ocean at the trenches. On land, sinking can occur along mountain ranges like the Himalayas.

One scientist has proposed that the earth is made up of six major blocks of land. These blocks of land move because of the spreading of the sea floor where the ridges and trenches are found.

E. Facts and Figures About the Oceans

(Display to be cutaway of Pacific Basin topography)

If you were to imagine the earth divided into ten parts, seven of those parts would be covered by water. The Ala Moana Building, in Honolulu, is about 107 m tall. The deepest depth, recorded so far in the ocean, is over 11,522.9 m in the Mariana Trench near the Philippine Islands. This means that over 108 Ala Moana buildings can be stacked up one on top of the other in the deepest part of the trench.

What do you think the ocean bottom looks like? Does it look like land with mountains, plains, and rivers? If you said it looks like land, you're right!

The ocean can be roughly divided into two areas called the CONTINENTAL MARGIN and the OCEAN BASIN. The continental margin is the shallow underwater area next to the continents. Hawaii doesn't have a continental margin. Many of the ocean's plants and animals live in the continental margin area. Most of the ocean basin is a plain with mountain ridges and deep, deep trenches. Hawaii is a chain of volcanic mountains that reach up from the bottom of the Pacific.

Hawaii is surrounded by the largest and deepest ocean, the Pacific Ocean. Magellan named our ocean "Pacific" after the Latin word *pacificus*. "Pacificus" means peaceful or calm.

The Pacific Ocean is over two times larger than any other ocean.

F. How did the Oceans Begin? What are they Like?

Scientists do not know the exact way the oceans began, but they have several THEORIES or ideas. One theory is that earth was formed from a cloud of cosmic dust and gas. This cloud was hot and as it cooled the dust and gas formed into a big ball. Clouds of steam formed around the earth. Many centuries passed before the clouds of steam cooled and rain fell. As more centuries passed, the basins began to be filled with water.

Today, much of the life in the sea is concentrated in the waters above the continental shelves. Because the water is shallow, sunlight penetrates to most of the shelf area. Actually, the continental shelves make up only about eight percent of the ocean's bottom, but oceanographers know a great deal about life found in this area because it is easy to get to. Over 4/5 of the ocean is more than 3,050 m (10,000 ft) deep. The average depth of the ocean, including the continental shelf, is 3,823.6 m (12,566 ft). Although it is known that quite a variety of life is found in the deep waters beyond the continental shelves, not too much is yet known about the animals and the deep water environment.

II. WORLD FISHERIES

Just think of the many products harvested from the ocean--fishes, seaweeds, oysters, whales, sponges, shrimps, pearls, corals, seals, crabs--the list is longer than this! The ocean also provides salt and other minerals useful to you. And think about all the fun you have at the beach! You can go fishing, swimming, diving or spearing. In Hawaii, over 100,000 people enjoy recreational fishing yearly. In 1975, Hawaii's commercial fishermen caught over $6,000,000 worth of fish.

A. Fisheries Catch Around the World
(Latest figures available--1974)
(Display to be a bar graph)

Selected Countries	Fisheries Catch (in metric tons)
Canada	1,027,254
Japan	10,773,355
Norway	2,644,930
Peru	4,149,888
Republic of Korea	2,001,348
South Africa	1,447,883
Spain	1,510,742
USA	2,743,673
USSR	9,235,609
Total of world	69,844,600

Fisheries catch includes tons caught of saltwater fish, freshwater fish, crustaceans, mollusks, seaweeds and other marine products. The figures are from the Food and Agricultural Organization as published in their Statistical Yearbook 1975.

B. World Resources

1. Whaling fishery

Whales belong to the order Cetacea and they have three suborders: Archaeocetic which are exclusively fossil, Mysticeti which are the baleen or filter feeding whales and Odontoceti or toothed whales which includes dolphins and porpoises. The important commercial species are the blue, fin, sei, Brydes, humpback, and sperm whales. Only the sperm whale belongs to the suborder Odontoceti; the rest are baleen whales.

Baleen whales feed on krill and other planktonic crustacea. Sperm whales eat squid and, sometimes, fish.

Modern whaling began in 1864, when Svend Foyn invented a new technique of using harpoon guns and steam-catcher boats to catch whales. With the development of efficient factory ships equipped with slipaways that allowed the whole whale to be taken out of the water, the number of whales began to decrease. Some whales are close to extinction. A treaty among certain countries was established to limit the number of whales being caught. These countries agreed to limit catch size, animal size, months when the whales could be caught and other items to help the whale populations recover. Although not all the countries that hunt whales have signed the treaty, they still limit their catch.

2. Tuna fishery

Japan catches about 2/3 of the world's tuna. Some of the kinds of tuna caught are skipjack, bluefin, yellowfin, bigeye and albacore. France and Spain fish for yellowfin, bigeye and albacore in the Mediterranean. The fishery uses the LONGLINE technique where lines are set out with baited hooks along the line every so many meters.

3. Menhaden fishery

This fishery is the largest commercial fishery in North America. It is found along the Atlantic and Gulf of Mexico coasts of the U.S. Menhaden feed in the rich coastal upwelling on plankton. They are caught by PURSE SEINING because nearly uniform-size fish move in dense schools. The purse seine used is a net about 366 m (1,200 feet) long and 18.3 to 27.4 m (60 to 90 feet) deep. Important species of menhaden are ATLANTIC MENHADEN, *Brevoortia tyrannus*, which are found off Nova Scotia to Northern Florida and GULF MENHADEN, *Brevoortia patronus*, which ranges from the west coast of Florida to Mexico.

4. Crab fishery

In the Pacific area, there are two species of crab of major importance. They are the KING (*Paralithodes camtschatica*) and the DUNGENESS (*Cancer magister*) crabs. King crab is harvested entirely in Alaska. Dungeness crabs are found along the southern California to Alaska coasts and in the Aleutians. These crabs are caught using POTS and OTTER TRAWLS.

There is a small KONA CRAB (*Ranina ranina*) fishery in Hawaii. Kona crab is harvested using baited LIFT NETS which are set 90 to 120 feet deep.

5. Lobster fishery

Three species of true lobsters are the AMERICAN, *Homarus americanus*, EUROPEAN, *Homarus gammarus*, and NORWEGIAN, *Nephrops norvegicus*. These lobsters support the commercial lobster fishery. The American lobster ranges from Labrador to North Carolina along the Atlantic coast. Maine is the most important state in terms of American lobster production. The European and Norwegian lobsters are fished from Norway to northern Africa and in parts of the Mediterranean. About ten times more American lobsters are landed every year than the two European species.

A wooden trap is the principal method of catching the American and European lobsters. Bait is dead fish. These lobsters are marketed live. Norwegian lobsters are taken in depths of over 182.9 m (600 feet) with OTTER TRAWLS.

6. Shrimp and prawn fisheries

More nations catch SHRIMP, than any other marine product. In at least 20 countries, shrimp fishing is a substantial industry. Because they have increased their catches during the last 10 years, India and Pakistan are now supplying a large amount of shrimp to the rest of the world. In the United States, the shrimp fishery from North Carolina to Texas produces the major portion of our shrimp. Shrimp are caught using OTTER TRAWLS. Two nets 45 feet each across the mouth are pulled behind the ship. The fishermen use a miniature trawl about 10 feet across to check to see how many shrimp are together before they drop the large nets. On deck the shrimp are sorted from the other animals. Freezing is a widely used method to prepare shrimp for marketing.

C. Sport Fishing

There are accounts of SPORT FISHING from Egypt that date from 2000 B.C. Angling with a hook and line are referred to in the Bible and in Latin works of literature. A Chinese painting in Tokyo, Japan shows a reel-equipped hand-held rod. The painting dates from 1190-1230 A.D. Sport fishing is an ancient sport. It is the art of catching fish for fun. Fishermen usually use a line with a baited hook or lure. Some use a rod or pole; others do not. There are two broad categories of angling or catching fish: freshwater and saltwater.

Ten years ago there were about 7,000,000 people in the USSR involved in sport fishing. Great Britain had 2,200,000 anglers in 1964. The US had 55,000,000 freshwater and saltwater fishermen in 1965.

A study done in the early 1970's estimated that Hawaii had 122,400 fishermen, 12 years old and above. The distribution of number of fishermen between the various counties is as follows: City and County of Honolulu, 92,500; County of Hawaii, 12,300; County of Maui, 10,600; County of Kauai, 7,000. Saltwater fishing was more popular than freshwater fishing. The largest number of persons fished from the shoreline (about 70%); other fishermen used boats or went diving.

(Display: data on sizes of fish caught or chart of freshwater fishing methods)

1. Hawaiian International Billfish Tournament

The first Hawaiian International Billfish Tournament was held in 1959 with 24 teams competing. It started with an idea of Peter Fithian; with the help of friends, businessmen, doctors, and the Hawaii Visitors Bureau and other persons, the tournaments were established. The participants catch Pacific blue marlin, tuna, striped marlin and other large game fish. It is now an internationally known event, held every summer in Kona.

Records:	
MEN	
Largest Pacific blue marlin:	916 pounds caught in 1973 by Eric Tixier
Largest ahi:	261 pounds caught in 1975 by Roger Anderson
WOMEN	
Largest Pacific blue marlin:	721.5 pounds caught in 1962 by Pat Peacock
Largest ahi:	250.5 pounds caught in 1976 by Judith Nakamura

1976 Catch

Fish	Number	Percent of Total
Pacific blue marlin *Makaira nigricans*	47	53.4
Shortbill spearfish *Tetrapturus angustirostris*	5	5.7
Striped marlin *Tetrapturus audax*	3	3.4
Black marlin *Makaira indica*	1	1.1
Tuna (all types over 100 pounds)	32	36.4
Total	88	100.0

D. Hawaii's Catch Statistics--1975

There are about ten to fifteen commercial fishes that make up about 90% of Hawaii's commercial fish catch. Estimates from the Fish and Game Division, Department of Land and Natural Resources on percentages for 1975 are as follows:

Skipjack tuna	52.0%
Ahi	20.0%
Akule	5.0%
Marlin (swordfish)	4.0%
Opelu	3.0%
Opakapaka	1.5%
Mahimahi	1.2%
Ono	1.2%
Ulua	1.0%
Others	11.0%

Since records have been kept from 1948, 1975 has the lowest recorded catch in terms of number of pounds of skipjack tuna caught. In 1975 4,414,828.8 kilograms (9,745,759 pounds) of commercial fish were caught with an ex-vessel value of $6,308,192. Ex-vessel value means the amount that the fishermen are paid for the fishes they catch. These statistics are taken from monthly reports turned in by the commercial fishermen.

The statistics show that aku is the most important commercail fish in Hawaii. In 1965 there were 16 fulltime and 2 parttime aku boats; about 9 persons go out on each ship per fishing trip.

Fish	Pounds Caught	Pounds Sold	Ex-vessel Value
Aku	5,054,178	5,054,178	$2,282,299
Ahi	2,161,000		2,126,000
Akule	511,432	442,623	307,318
Marlin	357,363		
Opelu	322,459	310,731	246,469
Ono	116,633	90,393	67,091
Opakapaka	161,310	136,462	174,347
Ulua	102,075	92,472	75,107

1. Hawaiian aku industry

Schools of aku, *Katsuwonus pelamis*, usually contain fish of the same size. These schools follow whales, basking sharks or even floating logs. Hawaii fishermen use the POLE AND LINE METHOD. Handfuls of nehu, *Stolephorus purpureus*, which is used as live bait, is thrown into the water and the movement of the baitfish attracts the tuna toward the fishing boat. The Hawaiian aku industry is dependent on baitfish. For some reason if there is no nehu, the fishermen can not go out to catch the aku. For this reason studies are being done to determine other baitfish that may also attract aku.

Aku has a strong tendency to form schools. These fish may school because traveling in schools makes it easier to capture prey; serves as protection from predators; and makes breeding easier.

Schools can be classified into 1) schools with sea birds circling overhead; 2) schools without birds; 3) schools with drifting objects; 4) schools with sharks; and 5) schools with whales. Birds are attracted to the schools because the feeding tunas chase small fish to the surface where the birds can feed on them. Schools congregate around drifting objects like logs, rafts, airplane fuel tanks, and other flotsam. The reasons for the fish to congregate around the objects is not known, but scientists guess that the objects may serve as substitutes for a reef or, perhaps, even serve as schooling companions.

Schools of aku stay with sharks and whales for protection. The shark's presence may protect the tuna from spearfish.

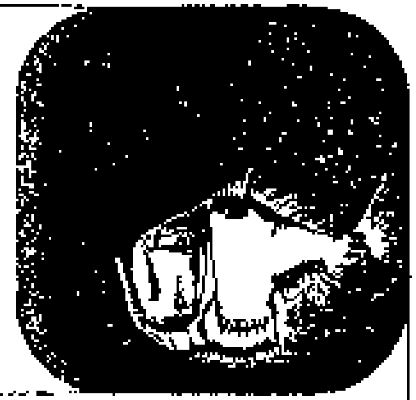
2. Biology of aku

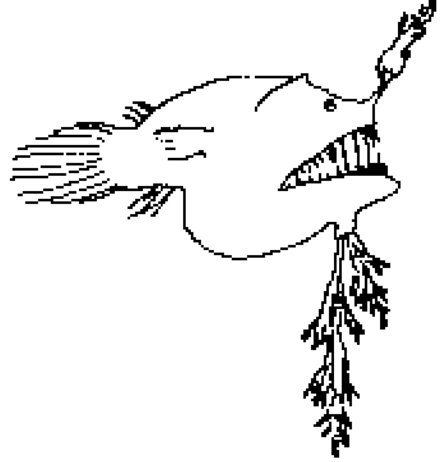
The skipjack spawn in midoceanic areas (tropical and subtropical waters) almost all year round across the Pacific ocean. In higher latitudes in the Pacific, spawning occurs during the spring-summer period.

How many eggs does one mama fish lay? Each female aku lays an average of 100,000 eggs. The ripe ovarian eggs are spherical, smooth and transparent. They usually contain a single oil droplet. The eggs are thought to be buoyant. The incubation period is about one day before the babies hatch. The babies feed on the yolk and as they grow, gradually change their diet to fishes, crustaceans and mollusks. Scientists have concluded that tuna will feed on whatever organisms are available. The fish feed approximately in the early morning from 0800 to 1200 and in the evening from 1600 to sunset. On the basis of data and calculations, the largest aku was probably in the 106.5 to 108.4 cm class with a weight of 32.5 to 34.5 kilograms (71.6 to 76.0 pounds). This fish was at least 12 years old.

Present areas of skipjack fishery are along the western coast of North and South America from California to Brazil; along the western coast of Africa; Hawaii, and in the waters east of Japan. The skipjack is found across all the oceans from 60° north latitude to 50° south latitude.

THE DARKEST DEPTHS





I. JOURNEY TO THE BOTTOM OF THE SEA

A. What Is This Place Like?

When you scoop up a handful of seawater it looks transparent. But if seawater really was transparent sunlight would be able to reach down to the very bottom of the ocean. However, because water particles and suspended material in seawater reflect, absorb and scatter light, light is only able to reach a few meters. What are the twilight regions and inky depths like? What other condtions must deep sea animals adapt to? Until special submarines were developed, scientists could not study the animals and conditions of the twilight and dark zones of the ocean. The bottom of the sea is a strange and cold place.

More than 70 percent of the surface of the earth is covered by the oceans. The average depth of all the oceans is 3832.6 m (12,566 ft) deep. The average height above sea level of all the land is only 840.6 m (2,756 ft). Mt. Everest, the highest mountain on land, reaches 8853.5 m (29,028 ft) above sea level. If Mt. Everest were placed into the bottom of the Marianas Trench, it would be 2.41 km (1-1/2 miles) below the surface of the ocean. The deepest spot in this trench is 11041 m (36,200 ft) or almost 11.3 km (7 miles) below sea level.

Most of the sea floor is known as the abyssal plain, far beneath the lighted surface zone, which reaches down to only 183 m (600 ft). More than four-fifths of the oceans is over 3050 m (10,000 ft) deep; and one-third of the oceans is over 3965 m (13,000 ft) below sea level. The abyssal plain around the Hawaiian Islands is about 5490 m (18,000 ft) deep. Mauna Kea rises up from its base on the sea floor about 9455 m (31,000 ft).

Scientists and engineers have developed special submarines to take with them all they need to survive in this strange and unfriendly place. Like men going out into outer space, divers must be protected from an environment that would kill them instantly.

The greater danger of the depths is the great pressure created by the weight of the water. Even submarines have limits to which they can dive down and not be crushed by the pressure of the water.

1. *Deepstar 4000*

Deepstar 4000 can dive to 1220 m (4,000 ft). It is a mini-submarine and was built in 1966.

2. *Trieste*

Trieste, in 1960, dove to the bottom of the Marianas Trench, the deepest spot in the world, 10919 m (35,800 ft) (about 11.3 km or 7 miles) below sea level. The *Trieste* is a bathyscaphe. It has a big float filled with gasoline, which is lighter than water. To dive, the *Trieste* fills some tanks with water and attaches metal weights to it. To surface, the water is pumped out and the metal is dumped. The gas float acts like a balloon and floats the men to the surface.

3. *Sealab III*

Sealab III is an underwater habitat or "house." Five teams of eight men stayed underwater for 12 days each. The habitat has beds, bathrooms, kitchens and laboratories where the men can live and study.

Land, on which people live, has many climates from tropical rain forests to deserts to snowy mountain peaks. But the sea looks the same. Actually the range of climates or conditions are greater in the ocean than on land. There are three things that determine the kinds of conditions found in the ocean. These are LIGHT, TEMPERATURE, and PRESSURE.

4. Light

A small amount of seawater seems to be transparent. However, particles of water and suspended material like plankton ABSORB, REFLECT and SCATTER light. Near the shore, where rivers and estuaries empty silt and other debris into the water, as much as 50 percent of the light is gone in 1.8 m (6 ft) of water, 75 percent at 4.27 m (14 ft), and 90 percent by 7.6 m (25 ft). Water gets cleaner away from land; the clearest waters are in the Sargasso Sea where light may penetrate five times deeper than in nearshore waters. There is only a thin layer of sun-lit waters from 30.5 to 99.1 m (100 to 325 ft) where photosynthesis can take place.

5. Temperature

Sunlight penetrates only a few hundred meters of the ocean. This makes the surface waters and ocean waters near the Equator, like in Hawaii, very warm. Sometimes the water is as warm as 32°C (90°F).

In the open sea the top layer of about 19.8 to 198.2 m (65 to 650 ft) has a warm and even temperature. Then the temperature falls very fast. The place where the warm and cold waters meet is called the THERMOCLINE. In a thermocline 152.3 m (500 ft) thick the water temperature may drop 11 to 17 degrees. In the next 305 m (1000 ft) to 366 m (1200 ft) the temperature drops very slowly to about 10°C (50°F). At about 1525 m (5000 ft) the rate the temperature drops has slowed down so much that even at that depth the temperature is 4°C (40°F).

The waters of the deepest trench or abyss is 3°C (38°F). The coldest waters at the North and South Pole is above -3°C (27°F).

The temperature range in the sea is then from -3 to 32°C (27 to 90°F). This range is smaller than that found on land.

6. Pressure

Pressure has the greatest effect on the conditions in the sea. The deeper one goes the greater the weight of the seawater above you becomes, this weight that presses in against you is pressure. One cubic meter (35.3 cu ft) of water weighs 4847 kg (2200 pounds). At 915 m (3000 ft) the pressure is about 100 kg per square cm (1500 pounds per square inch) or 100 times what it is at the surface. The great depths have pressures up to 500 kg per square cm (3-1/2 tons per square inch).

What caused the difference in the sizes of the heads?

The foam wig heads attached to the board above were dropped into the water at the different depths shown below the heads. Note the difference in the size at different depths.

The page from the log of the R/V *Machias* tells you how the experiment was done.

7. Deep Sea Sediments

Near the shore, the ocean bottom is covered by clay and rocks from land that has been washed into the sea. In places far from shore, the rocky bed of the sea is covered with two types of sediments.

Red clay sediments is made up of very fine particles of clay from the coastal areas. These particles were carried far out to sea by the currents until they finally settled on the sea floor. Buried in the red clay are the hard material that will not decay like the whale's earbones, shark's teeth and bits of meteorites.

Biological ooze are mainly made up of microscopic one-celled animals called foraminifera and the glass skeletons of microscopic plants called diatoms.

The "rain" of sediments on the sea floor does not stop. Layer after thin layer has settled throughout the ages. It takes about 5000 years to build up a layer of sediment 0.6 cm (¼ inch) thick. By studying the plants and animals in a sample of sediment, paleontologists are able to tell during which period of the earth's history these microscopic plants and animals lived. With new techniques in chemistry, they can also determine what the temperature of the sea was when these plants and animals were alive.

B. What Kinds of Animals Live Here?

Even if the deep sea is pitch-black, with water just above freezing and pressure great enough to crush almost anything from the surface, some animals still call this place their home.

1. Fish: abyssal adaptation

There are fish that look so different from the surface fish we know that people have called them the "weird monsters of the deep." They are not really monsters, the way they look has been determined by the environment they live in. It is the same with animals on land. Polar bears that live in the snow covered north have thick white fur coats to protect them from the cold and their color helps to camouflage them. Just as the polar bear is "dressed" for the environment it lives in, so are the animals of the deep sea.

The first thing you will notice about abyssal animals is their small size. This "monster" from the deep is drawn to its real size, only 7 cm (2 and 3/4 inches).

a. LANTERN FISH. The lantern fish is a mid-water fish that stays deep in the dark depths during the day and swims up near the surface at night to look for food. Sometimes on dark nights, opelu fishermen see this tiny silver blue fish at the surface. Because this lantern fish spends some time near the surface it looks most like the fish we usually see, except for its extra large eyes and the light along its body. There are more than 170 species of lantern fish each with its own pattern of lights. Males and females of each specie also have different body patterns. Being able to recognize each other is important in keeping the schools together and for the fish to find each other in the dark.

b. HATCHET FISH. These hatchet-shaped fish live below the sunlit zone in a place where the light is so dim the human eye could not see anything at all. Hatchet fish have very large sensitive eyes that can pick up shapes and shadows of things around them. Some hatchet fish have eyes like tubes that look upward for any food that it sees in the dim light overhead.

c. VIPERFISH. Viperfish cruise in the dark waters with its mouth open to show the lights it has inside. These lights are used to attract a tasty meal. Since food is very hard to come by, viperfish must eat what they can. They have long sharp uneven teeth to hold their prey and their jaws are made to open very wide to swallow fish and squid as big as they are.

Like the viperfish many abyssal fish have long thin bodies with weak trunk and tail because they live in relatively calm waters and do not have to fight the rough surge at the surface of the ocean.

d. <u>GULPERS</u>. The gulpers do just that--they gulp their food down. They have very large mouths but they do not have long teeth like the viperfish to hold their prey so they must swallow their prey very fast. Gulpers will swallow almost anything that comes along. The one pictured here is starving so its stomach is not showing, but when it gulps down a whole fish the stomach will stretch to hold it.

Gulpers have very small eyes. Since they are not able to see very well, they have developed a line of organs on the side of their long bodies and tails. These organs can detect vibrations in the water caused by other fish nearby. It can even detect the vibrations of a fish breathing.

e. <u>ANGLER FISH</u>. Deep water angler fish like the ones found in shallow water also "fish" for their meals. But instead of a fleshy worm-like "lure" on the end of a "pole," deep water anglers use a lighted lure. Only female anglers "fish." Male anglers are very small and must find a female to attach themselves to. He does this with special teeth and when he is permanently attached he becomes a parasite. That means he depends on her for everything.

Angler fish look very different from the other abyssal fish because they are almost as wide as they are long. They can not swim too fast to catch their prey so they hang in the water with their pole and lure and wait for some victim to come along.

2. Abyssal invertebrates

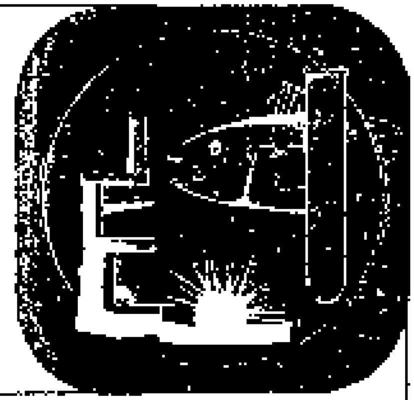
While the deep-sea fishes are small, deep water invertebrates (animals without backbones) are the largest animals. For example, the deep water ostracod, *Gigantocypris agassizi*, a relative of the shrimp is as big as a cherry while most ostracods are almost microscopic. Sea urchins with bodies a foot thick and giant orange crabs 6 feet across are found living in the deep. Hydras, a flower-like animal, which are usually only a few inches high grow to 8 feet in the deep waters off Japan.

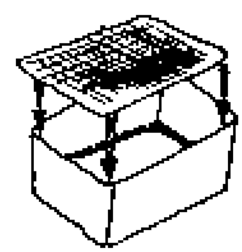
3. Who's who?

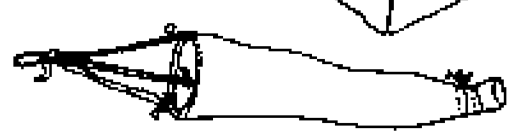
Abyssal or deep sea fish have "lights" on the sides of their bodies. These lights are a result of bioluminescence. Bioluminescence is light that is made by the animal. Abyssal animals use their lights in many ways. The deep-sea angler uses its light to lure its food toward it. Bioluminescence helps fish to recognize each other when they are schooling, looking for a mate or for something to eat.

Can you tell who's who?

SEALAB







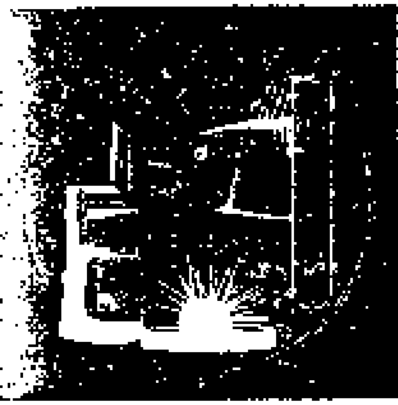
LAB SHEET

Name: Uhu or Parrot fish, Scarus

Size: 46 cm (18 inches)

SEALAB — LAB SHEET

NAME________________________



Animals change their form or develop functions to allow them to live in a certain environment. This necessary change is passed on in the animal through heredity. Only the best adapted survive and therefore the changes in the animal are strengthened to carry on the characteristics it needs to continue the species. Observe the specimen of the abyssal or deep water fish, draw and show how it is different and yet the same as a fish which lives in shallower waters.

Materials: ABYSSAL FISH SPECIMEN — LAB SHEET
MAGNIFYING GLASS — PENCIL

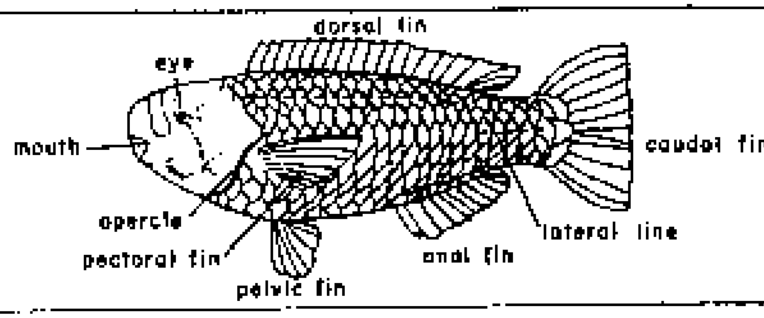
NEAR-SURFACE FISH:

Name: Uhu or Parrot fish, Scarus perspicillatus

Size: 46 cm (18 inches)

Location Found: Hanauma Bay, Oahu

Depth: 4.6 m (15 ft)



ABYSSAL FISH: Draw the specimen. Label the parts that you can see that is the same as the near-surface fish (diagram above).

Name:________________________

Size:________________________

Location Found:________________________

Depth:________________________

How is it different from fish that live near the surface of the ocean?

Makahiki kai
festival of the sea '77

SEALAB Lab Sheet

Discussion

From the characteristics listed below what kind of environment do you think the fish comes from.

1. extra large or extra small eyes -- dark

2. skinny, not very muscular -- weak swimmer, waters must be "calm"

3. fins -- small, of not much use -- steering (manuevering) not a problem, waters calm

4. skin -- soft, falling apart -- outer covering soft, no scales

5. teeth -- long, slender, very fine -- long teeth to hold on to what they catch; very fine -- not strong and molar-like for crushing, food must have soft body

6. large mouth -- swallow very large prey

7. "dots," or lights along body -- light show in dark -- must be for recognition of specie and sex

A PORTABLE PORTHOLE

(refer to student workbook, p. 28)

A look box that is relatively durable, inexpensive, and easy to construct consists of a plastic gallon jug with the bottom cut out and a half petri dish sealed into the hole. Half the top is cut away for viewing, leaving the handle intact for holding.

MATERIALS NEEDED:
- back saw
- scissors
- plastic gallon jug - 1 per student or pair of students
- silicone sealant - 1 tube for about a dozen look boxes
- plastic disposable petri dishes, size 150 mm x 15 mm - half dish per look box (see below for source of purchase)

*NOTE: Plastic disposable petri dishes, 150 mm x 15 mm, are sold in lots of 100 dishes by Van Waters and Rogers (VWR), and in lots of 10 by X-Ray and Medical Equipment, Inc., 3160 Waiona Street, Honolulu, Hawaii 96819. The retail price was $20.00 per box of 100 covered dishes, which comes to 10¢ per half dish. The top half of the dish is clear and makes a clear window in the bottom of the look box. The bottom half of one type of dish is scored in one-cm squares and provides built-in quadrats for making rough population counts.

The idea for construction of the gallon jug look box evolved during development of the Hawaii Marine Studies Science Project and the Hawaii Nature Studies Project at the Curriculum Research and Development Group, University of Hawaii.

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from *Aquaduat*

PLANKTON

In the study of ocean life, it is with the plankton that all things begin. The word plankton means "drifter" or "wanderer." Hence, all plankton are those creatures that must drift at the mercy of the currents because they are either too weak or too small to swim against those forces.

The kinds of things included in the plankton are such things as larval fish, baby crabs, tiny shrimp, bug-like creatures called copepods, one-celled plants called phytoplankton, and many, many other tiny creatures of the sea.

The plankton live in the surface waters of the ocean, and serve as the ultimate food source for many of the sea's larger creatures.

A HOMEMADE PLANKTON NET

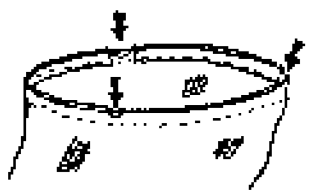
Scientists have special nets with which to capture plankton. The new is towed through the water behind a ship for 5 to 10 minutes, then is brought aboard for examination. This is how you can make a net using simple materials you may find around the house.

MATERIALS NEEDED:
- nylon stocking or pantyhose
- scissors
- needle and thread
- wire clothes hanger
- pliers
- about 15 feet of line
- baby food jar

STEP 1: Form a ring from the wire hanger, twisting the ends to form a smooth join.

STEP 2: Cut the stocking as in the diagram:

STEP 3: Sew the stocking onto the ring, leaving 3 evenly spaced 1/4" gaps where the bridle will be tied.



STEP 4: Fashion a bridle, knotting three 2' lengths of line together on one end. Tie the other ends to the hoop at the gaps.

STEP 5: Sew a hem on the other end of the stocking net so that it does not ravel. Then tie the jar on to the end of the completed net. Now you are ready for your first tow!

SEDIMENTS

Ultimately, all things that live in the ocean end up on the bottom. Fish, plankton, even whales that die eventually sink to the sea floor. Bones, shells, skeletal remains of all kinds of creatures make up a large portion of the sediments. Much of these remains are broken up into small pieces over the years. Other things in the sediments are pieces of rocks, gravel, sand and silt from the land.

We sample the sediments in waters too deep to dive by sending special instruments over the side of ships. Lowered on a cable, they scoop or "bite" a sample of the bottom so that it may be brought back up to the surface for examination.

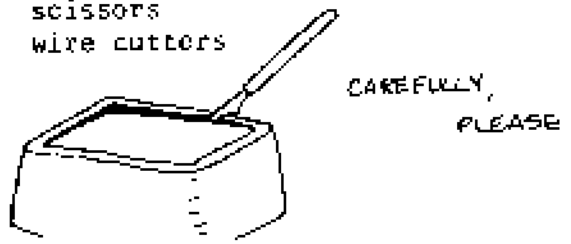
Back on board the ship, or on shore in a lab, we may go through the sediment sample to see what it contains. The first step in sorting a sand or sediment sample is sifting it through special sieves. In this way, the scientist can separate the particles by size.

Commercial sieves have special sized meshes and are usually made of brass or some other metal that will not rust or corrode in seawater. We can make homemade sieves that may not last as long, but will serve the same purpose!

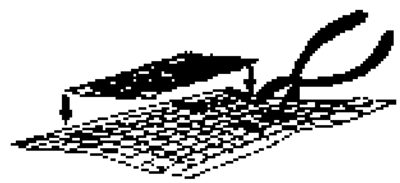
MAKING A SIEVE SET

MATERIALS NEEDED:
- 4 small plastic containers, of the same size and that can be stacked
- window screening
- X-acto knife
- 1/8" wire mesh screening
- 1/4" wire mesh screening
- silicone sealant
- scissors
- wire cutters

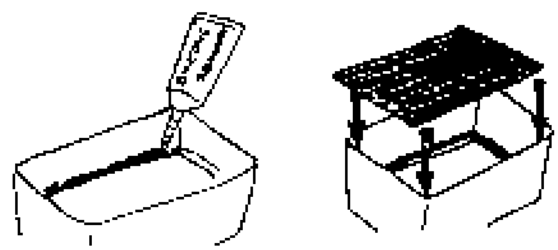
STEP 1: Using the knife, carefully cut out the bottoms of 3 of the plastic containers so that there is a small 1/4" boarder around the hole.



STEP 2: With the scissors, cut out a piece of window screening the same size as the bottom of your container. Using the window screening as your pattern, cut similar sized pieces from the two types of wire mesh screen with the wire cutters.



STEP 3: Squeeze a bead of silicone sealant around the bottom of one container on the inside. Insert the window screening, making sure that all the edges lie in the sealant. Press down.



STEP 4: Repeat STEP 3 for the other two pieces of screening that you cut out. Let all sieves dry overnight.

USING YOUR SIEVE SET: To sort a sample of the sediments, whether from the ocean bottom or a nearby beach, first take your sieve set and stack them with the largest sized mesh on top, the smallest on the bottom, and the whole container underneath that.
Take a handful of sediment and place it into the top sieve. With a cup, pour some water into the sieve, carefully shaking the sieves back and forth so that the sediment passes through the mesh. Repeat until each sieve has sorted its hsare of the sediment sample.