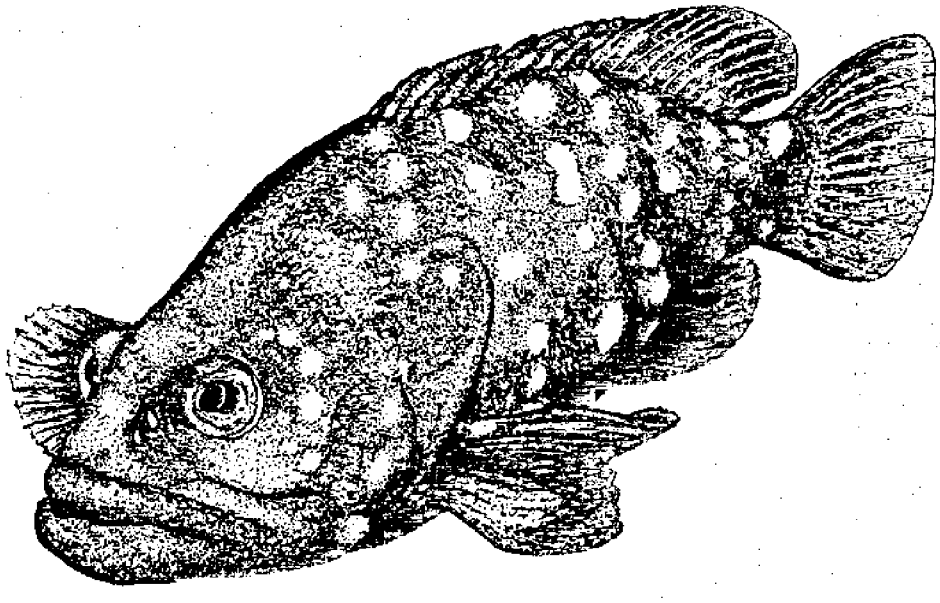
DOCENT HANDBOOK



Waikiki Aquarium
University of Hawaii

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CONTRIBUTORS

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We wish to thank those docents and teachers who gave us editorial help. Karon Chang typed the manuscript and gave us many suggestions.

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E. H. Chave & Phil Lobel

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HISTORY OF THE WAIKIKI AQUARIUM

The University of Hawaii's Waikiki Aquarium is a showplace for marine life and research by University of Hawaii's staff. It was established in 1903 through the efforts of James B. Castle, Charles M. Cooke, and Lorin A. Thurston, board members of the Honolulu Rapid Transit Company who acted as owner-managers. At the time, there were only two other aquariums in existence in the United States, one in New York and one in Philadelphia. The Aquarium continued as a privately financed and operated institution until 1919, when the lease on their land expired and the land reverted to the Territory. The Legislature then assigned the Aquarium to the University of Hawaii. Mr. F. A. Potter was our Aquarium's first director and in 1940 S. W. Tinker replaced him.

In 1949, the Legislature approved the issuance of bonds in order to gain funds for the rebuilding of the Aquarium. The City made a new site available for the Aquarium in an exchange of lands, and the new Aquarium was opened in its present location in January, 1955. The present building houses the aquariums on display as well as research laboratories and a lecture hall.

Following recommendations put foreward by the University and the State, the Aquarium is now attempting to focus its displays on the problems, life and general environment of Hawaiian waters. Our exhibits are undergoing changes to become media whereby people see marine life as it is and how it related to themselves. It is becoming a learning institution for student, tourists--anyone who wishes to come here. Hopefully we will all work hard to make the Aquarium Hawaii's window to the sea.

GUIDELINES FOR DOCENTS

Small groups are easiest to work with, and encourage more question-and-answer discussion. Develop your own way of working with the groups and your lectures will change continually as the material becomes more familiar. Flexability is the key to successful tour leading. Assess each group, decide the level of your presentation, and be willing to change approaches in the middle of the lecture if the group doesn't respond.

There are two kinds of class attitudes toward Aquarium field trips. The classes are either here for fun or they are here to learn. Of course class attitudes are usually determined by the teachers. Every docent deals with dicipline differently. If you make it clear how you expect the group to act, they usually cooperate. However, if you find that you are not in control, and the teacher isn't helping, quickly bring your lecture to a close. You are not here to babysit and the teacher should be able to control the class.

Speaking of closing--try to keep whatever you are discussing from dragging on to infinity. If people are getting squirmy, skip details, and hit the high points. Questions from class members are great but if too many are asked, it can be tedious especially for the students who are not participating.

Basket Lecture

Basket lectures are given to K-3 grades. The tactile experience helps to promote interest and understanding in young children. Having greeted the teacher and led the group to a suitable place to gather, seat the youngsters in such a manner that they can all see you and so that the sun is not shining in their eyes. They generally want to grab at the objects in the basket. If they are close enough to touch the basket during the lecture, just slide yourself and the basket a few steps out of reach. You will

find they will pay much more attention to what you say if they aren't trying to sneak a hand in to the basket to examine an interesting specimen.

Our experience has taught us that we cannot have an effective lecture while the specimens are passed from child to child. We therefore tell the class that the teachers and accompanying parents will hold the specimens for tactile examination after the lecture.

Lecture Room--Slide Presentation

Slide lectures are given to classes 4-adult whose teachers request them.

When you conduct a slide lecture tour, you should set up the lecture room equipment in advance if there is time. When the teacher notifies the window attendant of the class arrival, greet your class outside the front door and conduct them around to the lecture room. Hopefully, you will have remembered to open the back door, or have someone there to do so. Our room holds approximately 70 people. If the group is larger, we must give the lecture in two sections but this must be scheduled in advance. One section hears the lecture while the other tours the aquarium.

As we mentioned, you must try to determine what your approach to each group should be. On the way to the lecture room ask the teacher if the class has been prepared for the field trip. If they are out for a fun break from school, tell them how to act in the Aquarium and skip detailed discussions unless they ask for answers. In all cases, invite questions.

If you don't know answers, say so, and tell the students to write down the question and their name so that you can ask someone and give them an answer after the tour.

A few words must be said about ventilation. Our lecture room gets hot

and stuffy quickly. Two exhaust fans, front and back, can be used at low speed with minimal noise. If you leave the back doors open to the outside, and crack the door at the front of the lecture room, air can circulate freely. Small groups won't need such extensive ventilation, but large groups will, if you want them awake. When the class has left the room to begin their tour, remember to shut both back doors before leaving the room.

Lecture Room Set Up

When you arrive check the daily schedule. If a slide lecture is requested, set up the lecture room. The last team to use the lecture room is responsible for securing the equipment and returning the key to the projection booth.

Keys and locks are necessary. The projection booth key is kept outside the Education Office. Once inside the projection booth, you will find a cabinet locked with a combination lock. See education staff for the combination. All our lectures, tapes, tape recorder, and other Education Department equipment is kept in this cabinet. The key to the classroom display cases is also kept in the cabinet. The Dangerous Marine Animals lecture requires that you talk about and show the cone shells either before or after the slides so you'll need to open one of the cases to get the cones out.

Our lectures are taped on cassettes which syncronize with the slide projector. Normally, you will set up as indicated below. This directive is also posted in the projection booth. You will run through some practice set-up-take-down with a senior docent.

Directions for Equipment Set-Up and Take-Down

A. 1. Pull screen down.

B. 1. Open portable speaker, plug into socket by fan.

2. Plug grey line into recorder jack on speaker, attaching other end to grey line suspended from ceiling.
3. Switch power on.

C.
1. Plug into wall socket.
2. Plug grey line from speaker into speaker jack.
3. Insert cassette, side 1.
4. Turn recorder switch on.
5. If tape is not rewound, rewind it by pushing rewind.
6. Push start button on recorder.

D.
1. Mount carrousel on slide projector.
2. Plug cord into wall outlet.
3. Make sure black line from projector to recorder is connected at each end.
4. Turn projector on to low or high light.
5. Have someone turn out lights.

To Stop and Secure.

A.
1. Push stop on recorder.
2. Turn projector indicator to 'fan'.
3. Answer questions and dismiss class.

B.
1. Roll up screen.

C.
1. Turn speaker switch (power) off.
2. Unplug speaker from wall socket.
3. Unplug grey line.
4. Fold up speaker, store in projection room.

D.
1. Remove carrousel.
2. Turn projector fan to off.
3. Unplug projector.

E.
1. Rewind tape; eject.
2. Unplug recorder.
3. Black line between recorder and projector may stay connected.

F.
1. Cover all machines if possible.

Occasionally, you may wish to use a manual slide changer. This may be more effective for some groups, such as special education classes. The manual slide changer is a delicate instrument. This particular piece of equipment has been out for repair much too often, so please use TLC.

Touring

Our tour tactics vary according to the number of people we deal with, and when they arrive. Confusion seldom reigns except in the eyes of the onlooker. As you work with the seasoned docents tour patterns will take shape.

At the close of the Basket Lecture or Slide Lecture, explain the Aquarium tour. First tell them to enter the Aquarium and meet you and the other docents at the mosaic. (Depending on the number of docents they will be split up into groups there.) List the Aquarium rules. (1) Don't hit the glass. (2) Don't touch the turtles or seals. (3) No screaming. (4) No running--act like mature people.

If the Aquarium has a busy day, and you won't be able to talk to them as a group on the tour, tell them to ask you questions as you go around. You should not answer the Aquarium Tour Questions directly. Rather, direct students to the information that supplies the answers. This means you will have to know the questions and where the answers are.

On quiet days, you may find, especially with a prepared group, that you can give the group a quick talk in each area.

FISH ANATOMY

Skin

The skin of fishes has the following functions: lubricates by means of mucous so that the animals can swim faster; develops scales for protection from predators; contains sensory receptors which detect pressure waves in the water; and contains color cells for camouflage or warning.

Fins

The fins of fishes are used in swimming. The dorsal and anal fins control movement from side to side, the pelvic and pectoral fins control pitching and are used as brakes, and the caudal fin is used for foreward movement in most cases.

Swimbladder

The swimbladder enables fishes to maintain neutral buoyancy (to remain in one position in the water). Not all fishes have swimbladders. The swimbladder is used by fishes such as minnows for sound production. Electric eels and other air breathers use it as a respiratory organ.

Digestive, Circulatory and Excretory Systems

All fishes have an intestine which is divided into the mouth, esophagus, stomach, small intestine, large intestine and anus. Fishes have a liver, pancreas and other organs which secrete digestive enzymes.

The size of the fish's mouth correlates with the size of the food it eats. The mouth is usually equipped with teeth although some fishes like worm eels and trumpet fishes have no teeth and must suck up their prey. Fishes have fang-like, molar, file-like, canine or even fused teeth. All have numerous replacement teeth which emerge when a tooth falls out. Carnivores have individual sharp teeth and short intestines where-

as herbivores have file-like or fused teeth and either long intestines which are highly coiled or short intestines with many small blind pouches.

Besides having teeth in the mouth, many species have pharyngeal teeth in their throats. These are used for crushing prey and also when ground together, for sound production.

Marine fishes swallow salt water along with their food. It is absorbed from the intestine into the circulatory system. When the blood reaches the gills and kidneys, special cells remove the salts so that the concentration of salts in the blood is lower than outside the body.

Fishes possess a two chambered heart that pumps blood through their bodies in a closed system of arteries which lead away from the heart, capillaries which transfer oxygen and food to the cells, and veins which being the blood back to the heart. Special capillarybeds occur at the (1) digestive tract, (2) gills, and (3) kidneys to (1) take in food, (2) obtain dissolved oxygen and release carbon dioxide, and (3) release waste materials.

Reproductive and Endocrine Systems

The ways of reproduction in fishes are so varied that enormous books have been written to review the subject. Most fishes are either male or female throughout life. Like all vertebrates the male possesses testes in which sperm is produced and the female, ovaries for egg production. Usually millions of ripe eggs and sperm travel out of the fishes' bodies through tubes and are shed into the water. The fertilized eggs drift along and develop into larvae if not eaten. However, some male fishes, (sharks and "live bearers") may have intromittant organs (called **claspers** and gonopodia) through which they fertilize the female internally. Female fishes do not have a uterus but if

they are adapted to bear their young alive, the tube for carrying eggs (oviduct) is modified to handle the job. Embryos are not attached to the oviduct, instead, when they emerge from the egg, they rely on a yolk sac for food, or develop highly modified fins for absorbing nutrients. When the yolk sacs are used up the young emerge from the female's vent. Some fishes such as the tilapias and cardinalfishes pick up their newly fertilized eggs and brood them in their mouths until the larvae lose their yolk sacs. Other fishes such as gobies, damselfishes, and most cichlids build a nest and guard their eggs and young for varying lengths of time.

The endocrine system releases sex hormones into the blood which are responsible for spawning, sex reversal, reproductive color changes and many other factors. It also produces hormones such as adrenaline.

Sensory System

Fishes sense the environment around them in several ways.

Their eyes have a spherical lens for acute vision underwater just as our lens is flattened for vision through air. They possess a retina consisting of visual receptors, rods (and often cones) which are the terminal ends of the optic nerve. Rods detect small differences in the amount of light passing into the eye and cones detect color.

Their noses are tubular tunnels with two openings to the outside and lined with smell receptors. Their tongues contain taste buds.

Although their ears are internal--they have no opening to the outside--they can detect sound (pressure vibrations) passing through the water by means of tiny hair-like receptors.

Fishes have touch and often taste receptors in their skin and a lateral line receptor system. This latter system receives changes in pressure caused by disturb-

onces in the water. The lateral line and touch receptors has been highly modified in many fishes. Goatfishes have branches of the lateral line system in their barbels and use them for smelling and feeling their prey in the sand. Flying gurnards have developed special tactile receptors in their pelvic fins which they use in the same manner as goatfishes. Electrical fishes have highly modified electric sensors in their heads.

Muscular System

Fishes use their muscles in the same way as we do. Some fishes, however, have developed them for special purposes. Electric fishes have developed them and part of the nervous system into electric organs capable of producing electricity. Others such as the tuna have developed special muscles for swimming and gobies for creating suction in their pelvic fins.

If one notes the way different fishes swim, the muscles associated with that part of the body used will be well developed.

Respiratory System

Fishes breath by opening their mouths, taking in water and then closing their mouths thus forcing water over their gills and out the opercular opening. Dissolved oxygen is removed by the gill filaments. Several specialized freshwater fishes such as lung fishes which have developed lung-like sacs for holding and absorbing air and will drown if kept underwater.

REQUIREMENTS OF FISHES AND INVERTEBRATES IN THE AQUARIUM

All fishes and invertebrates in the aquarium are hand caught by our collectors using SCUBA equipment. They are brought to the aquarium and quarantined for two weeks or longer. Quarantine is most important because during this time the fishes are treated with copper sulfate, antibiotics, or formalin to rid them of their diseases.

Invertebrates are not treated because these chemicals kill them.

Fishes and invertebrates are given food and shelter which resembles their natural requirements as much as possible. Herbivores are given algae and "herbivore mix" which contains plant material, dry food, and vitamins. Carnivores are given pieces of fish, fish eggs, brine shrimp and "carnivore mix" which contains dry food, fish, meat, and vitamins. Animals with special diets (e.g. the pacu eats only fruit, the harlequin shrimp, sea stars) are treated accordingly. Some coral eating animals cannot be kept in the aquarium because a food mixture has not yet been developed for them.

Some animals need sand, others dark places, and still others coral or open water. The sets in the aquarium tanks are designed to fit the animal's needs and are continuously being improved. We do not keep some animals in the aquarium because their needs do not correspond with what we have available. The larger sharks cannot be kept in our small (500 gallon) tanks. Worms and brittle stars live under rocks and are never seen. Grey damselfish have large territories and fight with their tankmates. The boxfish and many nudibranchs are poisonous and if alarmed secrete a toxin which kills their tankmates.

IDENTIFICATION OF HAWAII'S MAJOR MARINE FISH FAMILIES

Marine teleost fishes have been in existence since Jurassic times and have invaded practically every part of the ocean. Teleostei is a subclass of the class Osteichthys (bony fishes) which also includes a few subclasses of primitive bony fishes, relicts of older times when teleosts were not numerous.

Teleosts are classified into lower, middle, and higher categories for convenience. Lower teleosts include several order of fishes exemplified in Hawaii by the ladyfish, Order Elopiformes, and eels, Order Anguilliformes.

The ladyfish (Family Elopidae) is an example of a typical lower teleost in that its single dorsal and paired pelvic fins are located centrally on its body.

Eels (Families, Muraenidae and Congridae and others) are more specialized than ladyfishes. They lack pelvic fins and/or pectorals. All are elongate with tubular nostrils and have long dorsal and anal fins. Their larval and internal features make eels lower teleosts.

Intermediate teleosts are exemplified by the Hawaiian squirrelfishes, Order Beryciformes, trumpetfishes, Order Syngnathiformes and lizardfishes, Order Myctophiformes. Again, most of the structures that unite them are internal, however, most of these animals are extremely bony or covered with protective armor.

Squirrelfishes (Family Holocentridae) are large eyed, red fishes covered with large sharp scales and spiny fins. Their opercles' bear from one to several large spines and there are four spines on their anal fins.

Trumpetfishes and their relatives, coronetfishes (Family Aulostomidae) have heads encased in bony armor and long tubular snouts. Their relatives, pipefishes and sea horses (Family Syngnathidae) are protected by rings of bony material and have

tubular snouts. The fins of all these fishes are placed far back on their bodies.

Lizardfishes (Family Synodontidae) have many sharp teeth in their mouths and an adipose fin.

The majority of bony fishes in Hawaii are called higher teleosts. These animals have less than five pelvic fin rays and their paired fins have moved foreward from the midline of their bodies. Other characteristics that separate them are internal. Several orders of higher teleosts occur in Hawaii. The Order Perciformes contains most of Hawaii's higher teleosts and includes:

Groupers (Family Serranidae) which have large mouths and prominant maxillaries. Their bodies are completely scaled and they have a single dorsal fin with spines and rays.

Hawkfishes (Family Cirrhitidae) which look like groupers but their lower pectoral rays are swollen into finger-like projections.

Big eyes (Family Priacanthidae) which have large eyes and small rough scales. Their bodies are either brown or red and they have a single dorsal fin.

Silver perch (Family Kuhliidae) which are silvery with notched dorsal fins and large eyes.

Mullets (Family Mugilidae) which have two dorsal fins and a folded jaw.

Cardinalfishes (Family Apogonidae) which have two dorsal fins, large eyes and a prominant maxillary.

Jacks (Family Carangidae) which have a bony keel along the caudal peduncle and a forked tail.

Goatfishes (Family Mullidae) which have two dorsal fins and barbels underneath their subterminal mouths.

Wrasses (Family Labridae) which have a single, long dorsal fin and an elongate body. Most use their pectoral fins for swimming.

Parrotfishes (Family Scaridae) which have jaws developed into a beak, a single dorsal fin and large scales.

Butterflyfishes (Family Chaetodontidae) which have a high body and spiny dorsal fin.

Angelfishes (Family Pomacanthidae) which have a preopercular spine, and a high body.

Damselfishes (Family Pomacentridae) which have one nostril on each side of its snout, a terminal mouth and a single dorsal fin. The lateral line ends underneath the soft dorsal fin.

Surgeonfishes (Family Acanthuridae) which have modified spiny scales on the caudal peduncle and high bodies.

Moorish idols (Family Zanclidae) which have pointed noses with orange saddles and elongate dorsal fins.

Gobies (Family Gobiidae) which have pelvic fins which are joined together and often form a sucking disk.

Blennies (Family Blenniidae) which have cirri on their heads and are elongate.

The Order Scorpaeniformes contains scorpionfishes (Family Scorpaenidae) which have toxic spines on their bodies. They have long spines on the preopercle and opercle, large mouths, and a horizontal bony ridge below the eye.

The Order Pleuronectiformes contain the flatfishes (Families Bothidae, and others). The eyes of flatfishes lie on one side of the head.

The Order Tetradontiformes includes the puffers, triggerfishes, and filefishes. Triggerfishes (Family Balistidae) and filefishes (Family Monacanthidae) have their first dorsal spines separated from the rest of the fin. Their pelvic fins are fused into bony processes. The dorsal spines of triggerfishes are located behind the eye whereas filefishes have their spine over the eye. Pufferfishes have oval or rounded bodies with scales modified into bony plates and beak-like mouths. They are divided into spiny puffers (Family Diodontidae) with large spines, balloonfishes (Family Tetradontidae) with small spines, sharpback puffers (Family Canthigastridae) with smooth skin, and box and cowfishes (Family Ostraciontidae) with box-like protective coverings.

The Order Lophiphormes contains the anglerfishes (Family Antennariidae) which have pelvic and pectoral fins modified into short, stubby, hand-like structures and a modified spine lure over the eyes.

HABITS OF COMMON HAWAIIAN FISHES

The following pages describe the habits of some of our Hawaiian fishes. The tank labels provide additional information. Please read them.

JACKS OR ULUA

Family Carangidae

The jacks are well known as fighting game fish. In Hawaii, adult jacks are called ulua and young ones, papio.

Ulua usually travel in a school and are voracious carnivores, feeding on any bite-sized animal they can catch. They grow large enough to swallow a football (although they have never been known to do so).

There are several species in Hawaiian waters and all are highly desired as a food fish. One of the most common species (Caranx melampygus) is sliver with blueish cast and yellow fins. Like all jacks it has bony scutes in front of its tail.

Sometimes small papio may join the goatfish called moano kea when it is digging in sand. The papio is probably waiting for the goatfish to uncover a fish which the goatfish can sense with ifs chin barbels. When the fish is scared out of the sand if the goatfish doesn't catch it the papio does.

SNAPPERS

Family Lutjanidae

Hawaii's common native snappers are deepwater forms which are caught with a hand line. The Opakapaka, onaga and other snappers are excellent food fish but arrive at the surface dead. This is because deepwater snappers, have swimbladders which allow them to hang in the water. If they are brought up too rapidly, they are unable to leak air out of their swimbladders fast enough and the whole structure bursts. This is why many fishes like snappers must be brought to the surface very slowly.

Introduced shallow water snappers, especially the blue lined snapper (Lutjanus kasmira), are becoming common in Hawaii and are also excellent eating fishes. These fishes form aggregations during the day and spread out at dusk to feed.

BASSLETS AND GROUPERS

Family Serranidae

Hawaii has only one real sea bass or grouper which is occasionally taken by fishermen. Epinephelus quernus is all black with white spots. This species of grouper is rare in shallow water and apparently lives more commonly around the 300 foot level. Other groupers have been introduced into Hawaiian waters as food fishes. These are sometimes taken by fishermen and can be found in the fish markets. Groupers are solitary animals and live on the bottom under ledges or in caves. They lie in wait for fishes to come by and then lunge at them swallowing them whole.

In the some family are the basslets or fancy basses. Instead of living on the bottom basslets swim above the bottom feeding on plankton. The basslets also differ from groupers because they live in large aggregations consisting of a few males and many females. Basslets and groupers possess the ability to change their sex from female to male or vice versa.

Our most common basslet is thompson's grouper. Most specimens less than 100 mm long are females while the larger fish are males. The males are territorial and are able to spawn several females. When one male becomes too old to spawn or falls prey to a larger fish, one of the females can change into a male and spawns with the females soon after. This ability to change sexes is not unique to the basslets. Wrasses and parrotfishes are also known to reverse sexes. The phenomena of sex reversal is still being studied and represents one of the more interesting aspects of fish behavior studied by ichthyologists.

EELS OR PUHI

Families Muraenidae, Congridae and Ophichthidae

The eels are among the most numerous and abundant Hawaiian fishes. There are several families but the moray eels, (Muraenidae) are the ones most often seen. There are basically two types of moray eels. The eels of the Genus Gymnothorax have long fang-like teeth, extended nostrils, and no paired fins. These eels feed on small fishes and soft-bodied invertebrates. Most of our eels are quite small but some species of eels are over 2 meters long and as thick as a man's thigh. The other type of eel, (Genus Echidna) has short, stubby, molar-like teeth which can crush mollusk shells. They feed mainly on crabs.

Moray eels can be vicious when teased. In most situations, however, eels retreat into their holes. Eels are adapted to live among the nooks and crannies of rubble and reefs. They rarely emerge from holes and generally only their heads may be seen.

Conger eels (Congridae) are silvery, nocturnal animals with large eyes. They differ noticeable from other eels by having paired pectoral fins and fleshy lips. During the day they inhabit caves but at night they come out and prowl the reef. The conger eels in our aquarium often turn upside down during the day. We do not know the cause of this behavior.

Snake eels (Ophichthidae) are somewhat like moray eels except that they are much thinner, have a larger upper lip, and a pointed tail. Snake eels bury themselves in the sand and like the congers are very shy. Some snake eels are confused with the venomous sea snakes. Sea snakes have been found on a few rare occasions in Hawaii and have paddle-like tails.

SQUIRRELFISHES

Family Holocentridae

Most people think of fishes as being diurnal, that is, awake during the day and asleep during the night. For most of the fishes this is true. However, there are several families of fishes that sleep during the day and become active after twilight. These are the squirrelfishes, big eyes, cardinalfishes, and silver perch.

Ala'ihi and menpachi both belong to a family of spiny nocturnal fishes which feed on bite-sized animals. During the day these fishes are found under ledges and in caves. At night the day fishes occupy these sleeping areas while the night fishes are found in the open. Night fishes are generally characterized by large eyes and red coloration. This red color is probably due to the storage of carotene in their bodies which is a pigment used in night vision. They obtain this from eating red shrimp just as we obtain the pigment from eating carrots.

Species generally called squirrelfish belong to the scientific genera Adioryx and Flammeo. They are named ala'ihi in Hawaii. Menpachi (Myripristes spp.) are named u'u. Menpachi look most similar to another nocturnal fish, the big eye (Priacanthidae), which has smaller scales and a truncate tail. Menpachi have a forked tail.

Our largest wquirrelfish, Adioryx spinifer is noteworthy because it possesses a poisonous spine on its opercle. Most squirrelfishes and menpachi grow to about 20 cm. in length while A. spinifer can exceed 60 cm.

CARDINALFISHES

Family Apogonidae

These small, reddish fishes are nocturnal, that is they live in caves and

holes during the day and become active at night. They have large eyes like the squirrelfishes, and two separate dorsal fins. The body form of all cardinalfishes is similar, making them an easy group to identify.

The cardinalfishes have an elaborate courtship behavior which is consumated when the female deposits her eggs in the male's mouth. The male incubates the eggs in his mouth until the young hatch, 3 to 4 weeks later.

Fishes which spawn and care for their young by brooding in the parent's mouth are classed as "mouthbrooders". Some other unrelated families of fish breed this way including some marine catfishes (Plotosidae), jawfishes and freshwater Cichlidae.

Cardinalfishes feed on most bite-sized animals including larval fishes, shrimp and crabs. They are easily kept in the aquarium.

SILVER PERCH

Family Kuhliidae

Silver perch are called aholehole in Hawaii. Young aholehole live in the planktonic community for several weeks before migrating to very shallow water. Many young aholehole live in tidal pools but as they grow older they move into deeper water. During the day adult aholehole live under ledges and emerge to feed on plankton at night.

GOATFISHES

Family Mullidae

Goatfishes are generally called kumu, moano, munu or weke according to the type. They are highly regarded as a food fish except for the nightmare weke (Upeneus arge) which is halucenogenic--if the fish is eaten one will have nightmares. U. arge has a banded tailfin which distinguishes it from other goatfishes.

The weke goatfishes (Mulloidichthys)aggregate in large numbers during the day, possibly to increase their protection from predators. It is harder for a hunting species such as a shark or ulua to sneak up on and attack a group of goatfishes since the combined sensory capabilities of all members make it harder to catch them unaware. As soon as a predator approaches, alarm is spread throughout the goatfish group which then precedes evasive action.

At dusk and dawn goatfishes split up individually or into groups of two or three and feed. They dig around in the sand using the barbels on their chin to "taste" various organisms before swallowing them.

Kumu, moano, and munu (Parupeneus) goatfishes may be seen feeding either during the day or night singly or in small groups. The fish eating moano kea has been discussed (see JACKS), the others of this group eat a variety of sand dwelling organisms and are often followed by wrasses or triggerfish which snap up animals unwanted or missed by the goatfishes.

HAWKFISHES

Family Cirrhitidae

Hawkfishes are characteristically found among corals and rocks. They are easily distinguished from other fishes since their pectoral fins have several thickened rays and are used to prop the upper portion of their bodies up consequently their Hawaiian name is pilikoa (clinging to coral). Often two or three species of hawkfishes live in the same area. They behave like groupers (Serranidae), sitting on the bottom, often partially concealed waiting for any soft-bodied fish or invertebrate to wander near.

The arc eyed hawkfish, Paracirrhites arcatus is found almost exclusively on the coral Pocillopora meandrina. When frightened it will hide deep between the

coral's branches holding itself in place with its pectoral fins. This species grows to about 10 centimeters in length.

Paracirrhites forsteri (the freckled hawkfish) is somewhat similar to P. arcatus except that P. forsteri grows three times larger. The juveniles of this species have a yellow stripe running the length of their generally dark body. The adults have a spotted head and a striped body.

Another species of hawkfish, Cirrhitus pinnulatus, is called po'apa'a meaning "hard head". This fish is mottled and is found alongside corals and rocks where there are other fishes.

In contrast to the preceeding hawkfishes, the two-spot hawkfish, Amblycirrhitus bimaculatus only grows to 8 or 10 cm. , has a smaller, more pointed mouth, and has a dark spot on its gill cover and on the flank just before the tail fin. It feeds on small animals living around reefs and is usually solitary.

The banded hawkfish, Cirrhitops fasciatus, is a small fish with deep red bars which hides in holes and crevices and behaves much like the longnose hawkfish, Oxycirrhites typus.

The longnose hawkfish is found perched among branches of black coral or on the ceilings of caves in water deeper than 33 m. This fish is brightly colored with a red criss-cross pattern which appears black in deep water due to the absence of red light.

These hawkfishes are often found grouped together, when perched they sit on their lower pectoral fin rays with their dorsal fin full erect. Their heads are pointed upwards (when sitting on the bottom) giving the impression of constantly looking upward. When on the roof of a cave, they appear to be looking down.

Often they will dart out and feed on prey that swim by or they may rummage among crevices for food. They feed on an assortment of other benthic invertebrates.

This species is negatively buoyant because it lacks a swimbladder. In order to swim without sinking it must use its pectoral fins as planing surfaces with the caudal fin providing the forward thrust. While swimming the dorsal fin is folded flat and the anal fin is extended to aid in stabilization. When maintaining a position in midwater, it beats its pectoral fins like a bird flaps its wings.

Several other species in different families and common to Pacific coral reefs, share the long-nose character. Our Hawaiian long-nose are: Forcipiger longirostris and F. flavissimus). The long-nose character is shared in these species probably as an adaptation for feeding on prey that live in crevices and between coral branches.

Another Hawaiian fish was at one time considered a member of the hawkfish family but is currently placed in this closely related family, Cheilodactylidae. There is one species, Goniistius vittatus, belonging to this family in Hawaii. This fish is commonly called by the Australian name, morwong.

G. vittatus differs most visibly from hawfishes by having a longer dorsal fin and a high head profile tapering back to the tail. Morwongs are not commonly found here but observations of the animals in our Aquarium indicate that they suck up coral polyps and algae with their fleshy mouths.

BUTTERFLYFISHES

Family Chaetodontidae

Some of the most colorful and conspicuous reef animals are butterflyfishes. Brillant coloration may aid in species recognition. This would help individual fishes find

mates, establish territories, or spread out over the reef. Bright colors may also serve to warn predators of a fish's inedability.

Dr. Ernst S. Reese (Dept. of Zoology, University of Hawaii) has studied these fishes and their habits and has revealed some very interesting relationships. He found that the butterflyfishes are divided into behavioral groups. Some species such as Chaetodon trifasciatus and Chaetodon ornatissimus travel in pairs feeding on coral. The pair wanders over a general area of the reef and does not defend a specific territory.

Other species feed on plankton and swim high in the water in large schools. Chaetodon miliaris, Heniochus acuminatus and Hemitaurichthys polylepis live this way.

Butterflyfishes may also be territorial or wander from reef to reef. Different species have different feeding habits. C. trifasciatus eats only coral polyps, C. ephippium feeds on sponges, C. reticulatus eats algae and C. miliaris picks at plankton. C. tinkeri named after Mr. Spencer Tinker, past director of the Waikiki Aquarium is a rare deepwater butterflyfish which travels in pairs and feeds on almost anything. Fish with such generalized habits are called omnivores. Animals that eat only plants are herbivores. Those species which feed only on other animals are carnivores.

The butterflyfish most sought after by aquarists because of unique behavior is easily recognized by its pecular elongated snout. The longnose butterflyfish is famous throughout the world and is frequently recognized as Forcipiger longirostris, however, a second species is actually more common. This species, Forcipiger flavissimus is usually the one found in aquariums. Both butterflyfish species are widespread throughout the tropical Pacific. They resemble one another closely; differing most apparently by the number of dorsal spines and the slightly longer "nose" of F. longirostris. In addition to

the common yellow form, F. longirostris has a black color phase. In the field, F. longirostris may be found most commonly in yellow-yellow or yellow-black pairs. F. flavissimus also travels in pairs and will frequently aggregate in caves and under ledges. The ecological relationship of these two species and the balck color morph is not well known and is presently under study. Both species feed on small crustacea which inhabit the crevices of coral and rock.

These longnose butterflyfishes are not overly aggressive between themselves or other species during the day. At night, however, there may be more hostile interactions as individuals compete for sleeping space.

Because of the unusually close similarity the two Forcipiger species have often been confused. Hobson and Chave (1972) summerize the results of this taxonomic name game. The ancient Hawaiians knew both longnose butterflyfishes as lau wiliwili nukunuku oi'oi refering to its shape, color, and extended snout. Common names of fishes in native communities are often based on the fish's use to the community. If it is an economically important species it may have several names, each referring to a different color form, sex or size. When a species or group of closely resembling species such as the longnose butterflyfishes are not vital they may be referred to collectively with a single name. Scientific names on the other hand, are more universal. Any scientific name change is well documented, refers to a single species and reflectsthat species believed evolution.

ANGELFISHES

Family Pomacanthidae

Undoubtedly, some of the most beautiful Hawaiian fishes are members of the Family Pomacanthidae. In Hawaii, there are three angelfishes in the Genus Centropyge; potter's angelfish, (Centropyge potteri), fisher's angelfish, (C. fisheri), and the flame angelfish, (C. loriculus).

The large grey and white bandit angelfish, (Holocanthus arcuatus) is also found in Hawaii. This fish lives along ledges in fairly deep water and eats sponges. The emporer angelfish has been seen here once but it was probably someone's pet which was let loose.

Of all the angelfishes, potter's angelfish is the most abundant. This species is known only from the Hawaiian Islands. Living on coral reefs, potter's angelfish feeds indiscriminately on the turf algae and associated detritus. Therefore, in the home aquarium, it is important that these fish are fed plant material.

The Centropyge angelfishes spend most of their time feeding along the bottom, occasionally swimming up in the water column picking at plankton. When a diver approaches, they duck into holes and "suspiciously" watch the diver. After a moment, the angelfish will come out. If the diver keeps out of the immediate "territory" of the angelfish, it will resume its daily activities.

The potter's angelfish is found in water as shallow as 2 meters and up to depths of 50 meters. At the greater depths (below 35 meters), they become scarce and fisher's angelfish becomes abundant. Observations indicate that their distribution may be related to available cover (i.e. places in which to hide from predators).

In the deeper water, the pieces of coral and rock rubble generally be-

comes smaller in size creating smaller crevices in which the angelfishes may hide. There seems to be a correlation between the size of available cover and the size of mature angelfish. Fisher's angelfish averages about three centimeters when mature while potter's angelfish often exceed ten centimeters. Being a larger fish, the potter's angelfish is able to drive the smaller fisher's angelfish from the areas of large rubble. Fisher's angelfish then seek refuge among the smaller rubble predominant in deeper water. Conversely, a full sized potter's angelfish living in small sized rubble may be unable to find a place large enough to hide from predators.

Fisher's angelfish is rarely seen on the tropical fish market probably because it requires a great deal of time to bring it up from the depths. After the fish is captured, it must be brought up slowly so that the fish can compensate for the changing water pressure by absorbing into its blood the excess gasses in the swimbladder. If brought up rapidly, the swimbladder will expand and burst causing the fish to quickly die. If brought up too fast, but slowly enough to prevent the swimbladder from rupturing, damage may still occur. The increased size of the swimbladder may cause excessive pressure on nearby vital organs including the kidney which lies directly above the swimbladder. Damage to these organs may lead to a slow death over a period of weeks. It can take as long as four hours to safely "decompress" a fisher's angelfish caught at depths below 35 meters. Potter's angelfish, on the other hand, is often collected in water less than 15 meters and can be brought into the boat after less than an hour of "decompression".

DAMSELFISHES

Family Pomacentridae

The appropriateness of the name "damsel" is quite inappropriate as it suggests some qualities of delicacy and gentleness. Most of these fishes are better known

as the warriors of the reef.

The most aggressive damselfish is Pomacentrus jenkinsi. This fish is all grey with occasional white markings on its side looking as if it has lost a few scales. P. jenkinsi feeds on algae and viciously defends a territory harboring his cultured crop. The territory size of P. jenkinsi has been shown to be of optimum size to allow a substantial growth of algae to supply the needs of each fish. In areas of dense algal growth, the territory is presumably smaller than in regions where algae does not grow as well.

Juvenile aloiloi or moon damselfish (Dascyllus albisella) may be found in branching coral heads or even in sea anemones to which they develop an immunity to the stinging tentacles. They duck into these when alarmed and rest there at night. During the day they spend most of the time hovering above their hiding places snapping at plankton. Aggregations of older Dascyllus feed high in midwater but also descend to the substrate and hide in holes when chased. Dascyllus are generally docile but like all damselfishes are extremely pugnacious while defending their eggs which they lay on the substrate.

Other less aggressive and generally inoffensive species are members of the genus Chromis. All these fishes live in groups sometimes containing a mixture of more than one species. They characteristically hover above the reef, facing into the current and feed on the plankton which drifts past. When frightened, these fishes dive into the coral cover.

WRASSES

Family Labridae

The wrasses are a diverse group of which large numbers of individuals can be found on a reef. Various species play many roles--from parasite pickers to fish

eating carnivores and are called hinalea in Hawaiian.

Sand dwelling wrasses belong to the genus Hemipteronotus. Species such as H. pavonius are called indian wrasses because of their feather-like first dorsal spine. These fish live over sand where they feed on any bite-sized fish or invertebrate that they can catch. When danger threatens they take cover by diving under the sand. They can excape a digging predator (such as a fish collector) by swimming sideways through the sand.

The peculiar bird wrasse, Gomphosus varius has developed a unique adaptation to feed on tiny animals that live between coral branches and in holes. This fish's long nose enables it to get at food other wrasse cannot reach.

The Hawaiian wrasse that especially picks parasites off the fins and scales of other fishes is Labroides phthirophagus which literally means "louse eater". This fish remains in one location on the reef called a "cleaning station" where other fishes called "hosts" come to be groomed.

In order to attract the cleanerfish, host fishes assume all sorts of weird poses such as extending all fins and standing tail or head upward. The cleanerfish displays a "signal dance" with which it draws the attention of preferred host species.

While the cleanerfish is inspecting a host for parasites it gently tickles the host with its pelvic fins. This tactile stimulation is rewarding. In other words fishes come to the cleanerfish to be tickled. Removal of ectoparasites is advantagous to host species and is the evolutionary reason for the relationship, although when a fish's parasites are removed it probably is painful because the host fish will turn and chase the cleanerfish.

There are many species of wrasses belonging to several genera (Thalassoma,

Chelio, Cirrhilabrus, Pseudocheilinus and others) which feed opportunistically on anything small they can sink their teeth into. Sometimes these fish will follow a goatfish or triggerfish and feed on food which either scares out from cover.

The wrasses belonging to the genera Cheilinus, Bodianus and Coris all grow large, often exceeding two feet in length. The adult fish feed on larger reef animals and only a few animals (like sharks) can swallow them.

The juvenile hogfish, Bodianus bilunulatus is blue with a yellow stripe along its back. This fish establishes "cleaning stations" much like the cleanerfish. As the hogfish grows it changes colors and becomes a predator. Female hogfish are red and white striped with black and yellow markings, large males are black.

In general, wrasses are elongate fishes with long continuous dorsal fins. They normally swim using their pectoral fins.

Many of the wrasses have distinct color phases between males, females and juveniles. All wrasses are able to change sex. Usually the larger, more brightly colored fishes are the males. Wrasse coloration led to a great confusion of names. In the Handbook of Hawaiian Fishes by W. Gosline and V. Brock the following changes should be made:

--Coris lepomis (blue) is the male of Coris flavovittata (striped)

--Coris rosea (rose) is the female of Coris ballieui (blue spots)

--Stethojulis axillaris (grey with red opercle spot) is the female and S. albovittata (red banded) is the male form of the species Stethojulis balteatus

--Anampses rubrocaudatus (red tail) is the female of A. chrysocephalus (psych head)

--Anampses godeffroyi (lines on scales) is the male of A. cuvieri (spotted)

PARROTFISHES

Family Scaridae

Parrotfishes, also called uhu, differ from wrasses in having larger scales and a beak of fused teeth. They are closely related to the wrasses and swim similarly. At night young parrotfishes and some adults encase themselves in a cocoon of mucous which supposedly protects them from predators such as eels which find prey by following their scent.

Parrotfishes feed on algae that has grown into coral rubble. The parrotfish bites off a chunk of rock and algae and grinds both up with the pharyngeal teeth in its throat. The ground up rock is extruded as fine sand. Parrotfishes are major contributors of sand, processing one or two pounds each day through their guts.

The different species of parrotfish are very difficult to distinguish and are generally just referred to by the generic name Scarus. The parrotfishes, like the wrasses, have many color varieties according to the individual's age and sex. What is even more confusing is that different species have very similar color patterns but trained ichthyologists can at least determine the males and females of each species. Identity of juveniles often cannot be made in the field.

SCORPIONFISHES

Family Scorpaenidae

The members of this family, called nohu in Hawaiian, are diverse in shape but all have spines which are poisonous to varying degrees and all are predators.

The most attractive of these fishes is the lionfish, Pterois sphex which is a miniature relative of the Indo Pacific turkeyfish, P. volitans. P. sphex pursues its prey at night actively with its pectoral fins spread wide. When within range it snaps

up its food--small fishes and invertebrates--in a single gulp. When not searching for prey this fish remains in holes on the reef and often hangs upside down on the roof of a cave.

Another lionfish (Dendrochirus brachypterus) also occurs in Hawaii and is similar in body shape and habits to P. sphex but differs by having shorter fins and duller colors.

One of the most interesting fishes is Iracundus signifer, the decoy scorpionfish. This species sits on the bottom and blends in with the rubble. It has evolved a dorsal fin which mimics a small fish in color and movement. When I. signifer is not on the prowl its dorsal fin lies flat along its back. When hungry, the dorsal fin is raised and a small black dot becomes apparent forming the "eye" of the lure. I. signifer then waves the dorsal fin lure until a fish attacks and is eaten.

Using the dorsal fin as a lure is a sophistication over most rockfish species which are merely camouflaged and have to wait until a small fish swims closely by.

The unusual scorpionfish Taenianotus triacanthus has taken a different developmental path. This fish is highly compressed and sits among coral and rubble swaying with the surge and currents. This species resembles a leaf of seaweed and like the rockfish, uses this ability to hide, waiting for a bite sized fish to swim within feeding range.

The toxic qualities and venom apparatus of scorpionfishes have been thoroughly studied. Although Hawaiian species have not proved fatal there is always the possibility depending on the individual stung. Scorpionfishes do not use their toxic spines offensively, any danger that may exist stems from careless handling.

If you are stabbed, get out of the water, apply a constricting band above

the affected area, and place it in as hot water as you can stand for 15 to 90 minutes. The hot water breaks down the toxin and the tourniquet prevents it from being rapidly carried to the rest of the body. See a doctor as soon as possible so that he can clean and examine the puncture.

CHECKERED SAND HOPPER

Family Parapercidae

Parapercis schauinslandi is the only member of this family kept in the Waikiki Aquarium. This is a bright checkered red fish which lives on the sand where there is scattered rubble and pen shell beds. It builds burrows in the sand under rocks into which it retreats when approached. The males are larger and have flowing, filamentous fins. They are territorial spacing themselves throughout an area, allowing only females within their territories. The females appear to sub-divide the male's territory between themselves. This territorial behavior enables the male to spawn several females and allows each female her own nest.

The checkered sand hopper feeds on most organisms it can swallow. It finds food on the sand and also while swimming above the bottom it picks at plankton passing by.

BLENNIES

Family Blenniidae

Blennies are those small, elongate, black or brown fishes that are commonly found in tidepools, but other kinds of blennies such as a large form called Exallas brevis live in coral communities. Tidepool blennies are able to tolerate many environmental extremes such as high temperatures and brackish or hypersaline water since tidepools are subject to the blistering sun and rains as well as changing tides. Blennies are

also exposed to predation by birds. As a partial means of protection, blennies are able to escape predators by leaping from one pool to another. They rarely miss a neighboring pool even when jumping over dry rocks. It is possible that these blennies learn the location of neighboring pools during high tide.

Blennies have many fine, comb-like teeth for scraping algae off rocks. They possess two "cirri" above the eyes, which look like long, bushy eyebrows. They are generally mottled and blunt faced.

GOBIES

Family Gobiidae

Gobies are found just about everywhere fishes can live, holes in sandy flats, deep water ledges, and coral reefs. They have a torpedo-like (fusiform) shape and small beady eyes. Their pelvic fins are fused together into a cup and are able to use this adaptation as a suction disc to hold onto rocks in surge zones.

Gobies breed in pairs and are territorial, chasing away others of their own species. Males court by emitting chemicals called phermones and by making sounds. These signals attract a mate and serve to ward off intruding males. After a female lays her eggs on the underside of stones, the male guards them until they hatch.

Gobies are easily maintained and several species have been bred and raised in captivity. Among the species that have been raised is Gobiosma oceanops, the cleaner goby in the Atlantic. This goby picks the parasites off other fishes just like the Pacific cleaning wrasse Labroides. The cleaner gobies inhabit coral heads. When a fish wants to be cleaned it must pose on the coral head. The cleaner goby will then come out and clean the posing host fish.

FLATFISHES

Families Bothidae and Pleuronectidae

The flatfish is definately unique. It begins its life as a larva in the plankton and resembles a normal fish in shape. Only when it settles on the reef does it transform into a specialized sand flat predator. The flatfish lies on its right or left side depending on the species so to be flat as possible and one eye migrates until both eyes are together in the top side.

The flatfish has the remarkable ability to blend perfectly into its surroundings. It is able to accomplish color transformations by specialized pigmented cells in its skin. Many scientists believe that the fish mimics the background using its nervous system to expand or contract the pigment cells to match what its eyes perceive. However, there is some evidence that other factors may also be involved.

Flatfishes feed on benthic crustacea and small fishes. They ambush their prey by darting out at them from an almost buried position. Flatfishes are commonly eaten by predators such as papio which prowl the sand in search of food. In Hawaii, the flatfishes are small, seldom exceeding a foot in length. Our most common form is Bothus mancus. In cooler waters however, flatfishes are known by such names as halibut, flounder and sole. Several grow to enormous sizes, e.g. one species aptly named the barn door halibut, reaches a length of 2-1/2 meters and 250 kilograms in weight.

MALACANTHIDS

Family Brachiostegidae

Malacanthus hoedti is found throughout the Pacific ocean, living in burrows on the sand flats. This animal is commonly called the sand tile fish.

It lives in burrows into which it escapes head first when frightened. The

sand tilefish feeds primarily on brittle stars, crabs, mantis shrimps and fishes. In its normal daytime attitude it can be seen hovering above its burrow, occasionally darting after a piece of food.

Tilefishes build long horizontal tunnels beneath the sand and then cover the trough with large fragments of shell, coral and rock, leaving one or two openings at the ends.

They are territorial and defend areas about 10 meters square from others of their kind but do not seem to mind the presence of other species. They frequently occur in pairs but the sexes are not easily distinguished.

ANGLERFISHES

Family Antennariidae

The anglerfish is so named for its habit of luring small fishes by its first dorsal spine which is modified into a fishing pole. Part of the spine is transparent with a small fleshy tip resembling a worm. The anglerfish wiggles this lure in front of its mouth and a small fish hoping to get a meal soon becomes one. The anglerfish has no large teeth and swallows its prey whole with one gulp. Anglerfishes crawl on their pectoral fins and are able to grip onto a coral or rock using their finger-like rays. Small species live between coral branches and grow only a few inches long. The largest Hawaiian species lives among boulders and grows to about a foot in length.

An anglerfish can change its color from black to white with mottled patterns of all colors in between. This ability is not unique to the anglers. The leaffish (Taenianotus triacanthus) and scorpionfishes (Scorpaenopsis spp.) have similar life styles, eat the same foods and have many color variations.

SURGEONFISHES

Family Acanthuridae

Surgeonfishes are very common reef fishes often called tangs. Most have Hawaiian names. These fishes have a pair or two of modified bony scales at the base of the caudal fin which is blade-like and is used for defense. They use their caudal blade-like scales to whip around and slash an enemy when they are grabbed by the head since most predators approaching a fish will attempt to swallow their prey head first.

The achilles tang, Acanthurus achilles has a brilliantly bright orange spot around its blade. This may serve as a warning coloration to draw attention to the potentially dangerous blade. The blades of several other surgeonfishes are outlined or colorful. Acanthurus surgeonfishes travel in schools and feed on algae. The commonest of these is the banded surgeonfish or manini.

While most of the Acanthurus species feed on algae, the unicornfishes (genus Naso) feed on plankton. Unicornfishes travel in large schools in midwater and are distinguished from Acanthurus by having two spine blades on each side of their tails. These blades are rigidly fixed whereas the Acanthurus species have a single retractable blade. The most peculiar unicornfish is N. unicornis, which develops a long "unicorn horn" on its forehead. The function of this unique adaptation has not yet been revealed.

Another group of surgeonfishes is the algae-eating tang which belongs to the genus Zebrasoma. Sailfin and yellow tangs are commonly kept in aquariums but they are difficult to maintain unless coerced to eat dried food. Yellow tangs are commonly seen in many different reef areas whereas sailfin tangs are restricted to quiet bays.

MOORISH IDOL

Family Zanclidae

This species is a highly stylized reef fish whose body form is highlighted by a long, flowing dorsal fin. It resembles the butterflyfishes (Chaetodontidae), especially Heniochus acuminatus. It is, however, more closely related to the surgeonfishes (Acanthuridae).

The moorish idol is not easily kept in aquariums; on the reef it feeds on algae and sponges. It is sometimes found in schools but most often it travels in pairs or singly. This fish is most active during the daylight hours, its banded colors of black and yellow-white make it stand out among other reef fishes. At night it retires to semi-covered spaces and changes its yellowish-white areas to brown.

The moorish idol is the only member of the family Zanclidae. Its scientific name is Zanclus cornutus. In Hawaiian it is called kihikihi which refers to the angular geometry of the moorish idol's body shape.

TRIGGERFISHES

Family Balistidae

Triggerfishes or humuhumus are among the most advanced of reef fishes. "Advanced" in evolutionary terms means they have undergone a great many changes to reach their present condition. Triggerfishes are in the same order as puffers and filefishes and are common in Hawaii. One of their special adaptations is a modified dorsal and anal spine with which they wedge themselves into holes. They also have several spines along the caudalpedunclefor defence against predators and their eyes are able to move independently, one watching for predators, the other for prey.

Triggerfishes have fused teeth, somewhat similar to parrotfishes and feed

on hard-shelled mollusks and sea urchins. They also eat shrimps and octopus as well as small fishes. Triggerfish uncover animals in the sand by blowing water over it and often a triggerfish will travel in the company of a wrasse and goatfish, all having different means of detecting and unearthing prey in the sand.

Rhinecanthus aculeatus and R. rectangulus feed in this way and are known to tourists because of the song of the "little grass shack where the humuhumu nukunuku a'pua'a swim by".

A few triggerfishes feed on plankton. The humuhumu ele'ele (black trigger) Melichthys niger is often found 5 to 10 meters above the bottom feeding among schools of unicornfishes and butterflyfishes. Xanthichthys mento also feeds on plankton.

Triggerfishes are most similar to but easily distinguished from the filefishes (Monocanthidae). The single dorsal spine of filefishes is located directly over the eye while the spines of triggerfishes are located behind the eye.

Triggerfishes also differ from other reef fishes by their peculiar mode of swimming. They do not use their caudal fin but rather undulate their dorsal and anal fin simutaneously. Sometimes they swim vast distances over the reef. While being pursued they make loud grunting sounds which may serve as a warning to nearby triggerfishes.

FILEFISHES

Family Monocanthidae

Filefishes are small laterally compressed animals with diamond shaped bodies. Although most species are small, a few attain lengths of 1 meter and generally inhabit deeper waters. These are the Alutera spp. or broom tailed filefishes.

The most common species are the black head (Pervagor melanocephalus) and the orange tail (P. spilosoma) filefish. These fishes live among coral reefs feeding

on very small fishes and shrimps. They often engage in battles with others of their species.

During a fighting bout, both animals are usually side by side, facing the tail of the other. In this position they flare their fins and rapidly flick their dorsal spine. As the fighting bout progresses, displaying is followed by chasing in a rapid circle and ends in one fish being driven away.

PUFFERS, BOXFISHES AND COWFISHES

These fishes are members of a large order of fishes that is one of the most highly evolved of all groups. These fishes are noticably different by the way they swim and by the structure of their jaws. There are three families of puffers; the sharpnose puffers, Canthigasteridae, the giant puffers, Tetradontidae and the spiny puffers, Diodontidae.

Sharpnose puffers are common and only grow to about four inches in length. There are several species in Hawaii of which the spotted puffer (Canthigaster jactator) and the banded puffer (C. coronatus) are the most common. Sharpnose puffers are often found in pairs, are territorial, and feed on small benthic invertebrates. Giant puffers are slow moving, solitary animals often found hiding in caves. They eat larger invertebrates such as sea urchins, sea stars and crabs. A giant puffer's means of protection is to inhale water thus increasing its size, to the extent that it is too large to be swallowed by most reef predators.

The spiny puffers are also able to swell with water to increase their girth. They have the added protective feature of possessing many sharp spines. Spiny puffers have sharp beaks with which they grind up mollusks and other benthic invertebrates such as crabs. Cowfishes and boxfishes are closely related to the puffers but differ markedly in one adaptation. While the puffers have evolved to become very flexable in order to

swell, the cowfishes and boxfishes (Family Ostracionidae) have developed rigid bony box-like armor for protection.

Cowfishes are distinguished from boxfishes by having two horny projections on the heads. Boxfishes, especially Ostracion meleagris are able to secrete a toxic mucous which kills or repels potential predators. For this reason these species should not be kept in closed aquarium systems since this toxin can kill the other fishes present. Cowfishes (Lactoria spp.), on the other hand, are excellent aquarium pets which are quickly tamed.

Since boxfishes and cowfishes are encased in rigid armor, they use their fins for propulsion but are unable to quickly beat their caudal fins because of the armor near their tail bases. Consequently, they move by beating their pectoral fins. Boxfishes and cowfishes generally feed on benthic invertebrates and occasionally on larval fishes. Usually one or two may be seen while diving on a reef.

SEA ANEMONES, CORALS, JELLYFISHES

Phylum Coelenterata

The body form of sea anemones, corals, and jellyfishes is essentially a sac with a single opening or mouth surrounded by tentacles. In sea anemones and corals these sacs are called polyps. Each polyp or colony of polyps is attached in some way to the substrate. The sac-like bodies of jellyfish float upside down and are called medusae. Many anemones, corals, and jellyfishes are brightly colored. This gaudy coloration sometimes gives warning that the animal may be dangerous or not good to eat. All sea anemones, corals, and jellyfishes contain stinging cells (nematocysts) in their tentacles which are expelled when a tentacle is touched.

Sea Anemones

Sea anemones are single polyps which can be found attached to rocks (the brown anemone, e.g. Aptaisia) or in the quiet sandy lagoons (the sand anemone, e.g. Radianthus) of Hawaii. Anemones are not as common in Hawaii as in colder water. They are able to creep about but this process is so slow that only after some hours can one notice that the animal has moved. They feed on small planktonic animals that they catch with their tentacles.

Corals

In a coral colony all the polyps are connected by tissue which transports the digested food from polyp to polyp so that if one polyp catches and eats a piece of food, many of its neighbors also get some nourishment. Coral polyps secrete skeletons of calcium carbonate (lime). Most coral heads are white skeletal material and the living tissue is a thin skin surrounding it.

Reef building corals are associated with one-celled algae called zoo-

xanthellae. Zooxanthellae live within the coral tissues and manufacture food for themselves and the corals by converting light energy to chemical energy (photosynthesis). In order to do this, zooxanthellae need sunlight. This is why reef corals are not found in waters below about 30 meters in depth. Reef corals grow at a rate of about 1 to 2 cm per year. As they grow upwards, reef algae called coralline algae grow into their bases. These algae produce a calcium carbonate cement which strengthens and binds the corals together forming the reef network. Since strong wave action, boring sponges, oysters and other factors break down the living coral heads and the reef base, the corals and coralline algae must grow continuously to produce a viable reef.

Corals need clean, well oxygenated water in order to grow. Sewage and silt pollution settles on corals and kills them. Therefore, in some polluted areas in Hawaii, e.g. Kaneohe Bay, the corals are dying and the reefs are being eroded. However, on a viable reef, if coral heads die, one can usually see smaller heads which are growing to replace them.

The reef network has millions of holes in it providing homes for the other reef animals. Therefore, if coral reefs are destroyed, the animals within it and their predators also die.

We have four common types of reef building corals in Hawaii:

Pocillopora meandrina mostly lives in the surge zone where most other corals do not grow. These sturdy corals are usually brown or pink when alive. They are the ones most commonly bleached white and sold as souvenirs.

Porites compressa, the yellow finger coral, lives in areas where wave action is light. Extensive patches of this coral may be seen below 50 feet in depth in

quiet water.

Porites lobata is a yellow lobed coral found in shallow boys or in deeper water. It often forms large heads which sometimes contains many grooves. These are made by snapping shrimp which burrow in the heads and may be seen moving through the channels in the coral searching for food.

Montipora verrucosa is usually light brown in coloration and forms brittle plate-like or cauliflower-like colonies. It is a denizen of quiet, calm bays and tends to grow faster than Porites or Pocillopora.

Two common shallow water stony corals not considered to be reef builders are Fungia and Tubastrea. Fungia, the mushroom coral, is a single polyp. When a young coral settles on the reefs in quiet water it grows a stalk. This stalk eventually breaks and the coral becomes free living. If it becomes turned over or is covered with sand, it can free itself by taking in water at one end and tipping itself over. This process takes several hours. Tubastrea aurea ranges from orange to black in color and lives in holes in the reef. Since the polyps do not contain zooxanthellae, they catch and feed on plankton which comes in reach of their tentacles.

Black and pink precious corals live in water too deep for zooxanthellae to live and also must catch their own food. Their outer skin of large tentacled polyps catch plankton from the water.

Jellyfishes

A jellyfish consits of an umbrella-like bell which pulses with an open and closing motion to move it through the water. Like other coelenterates, jellyfish have a digestive cavity and a long set of tentacles containing cells with stinging nematocysts. These nematocysts contain poisonous barbs which are triggered when the tenta-

cles are touched. Some small fish, like the golden ulua live in the umbrella of jellyfishes for protection. They avoid the tentacles for if caught, they are paralyzed by the nematocysts and eaten by the jellyfish.

The portugese man-of-war is our most dangerous jellyfish. After a storm, these purple jelly-like creatures may be seen washed up in great numbers on our windward beaches. Even after it is dead, the portugese man-of-war should not be touched because the nematocysts may still be active. Associated with these jellyfishes and also often washed up on our beaches is a small purple snail (Janthina) which eats them and is not harmed by the stinging cells.

SPONGES

Phylum Porifera

These animals have no local names because they were not used as food by the Hawaiians. They come in a variety of colors, are attached to rocks or pilings and feed by filtering particles from water by circulating it through their bodies at a rate of several gallons per day. Some of the larger sponges can be found in areas rich in nutrients, especially in semi-polluted regions of Hawaii.

If you take a sponge and squeeze it through cheese cloth, the minute groups of cells will regenerate into new sponges. Likewise, if a parent sponge is affected by unfavorable conditions, it breaks apart and its cells hopefully are carried to a more favorable place to grow again. The skeletons of sponges may be soft and pliable such as in the bath sponge but in Hawaii they usually have tiny spicules of lime or glass. It is not wise to handle sponges since the spicules will imbed in your skin and itch.

FLATWORMS

Phylum Platyhelminthes

Marine flatworms are often brightly colored and usually found in holes and under rocks in the reef. They are not good to eat and some may break apart and emit a substance which may kill other animals within a confined area. They have no segments in their bodies, are very flat, and may reach 5 cm in length. They feed by crawling over their prey including oysters and tunicates and digesting them with juices secreted from their slit-like stomachs. Flatworms may mate or they may simply split into many pieces, each growing into a new flatworm.

BRYOZOANS

Phylum Ectoprocta

The lace coral is not a coral at all but rather a colony of bryozoans. The animals in the colony suck in tiny animals and plants by creating currents with the cilia on their tentacles. Bryozoans such as this one build a pink lace-like skeleton and are usually found in caves. Other bryozoans are soft and pliable. They are unmistakable under the microscope because each little animal is encased in a box-like covering.

TUBEWORMS AND BRISTLEWORMS

Phylum Annelida

Tubeworms and bristleworms are relatives of the earthworm. They possess long segmented bodies and on each segment lie a pair of bristles. These marine worms vary in shape from tiny, thread-like animals to large (up to 45 cm) worms whose segments are equipped with paddle shaped lobes used for swimming.

On Hawaiian reefs the most commonly observed tubeworms feed by means of their feathery tentacles on fine particles in the water. When the tentacles are cover-

ed with food, the worm pulls them into its body and the food is digested. Another common tubeworm is called the spaghetti worm because its long white sticky tentacles resemble noodles. When food becomes trapped in these tentacles they are reeled in and the food is scraped off. Each tubeworm species digs a burrow in the mud or builds itself a leathery or calcareous tube in which its worm-like body is concealed and only its tentacles may be seen. It's bristles enable it to crawl up and down its tube and if danger threatens, it can pull its tentacles into the tube faster than the average movie film can record the action.

Bristleworms have eyes and a pair of horny jaws. They also have paired bristles on each segment of their bodies which they use to crawl about in search of their food--small invertebrates, including other bristleworms. One of the most conspicuous bristleworms on local reefs is Eurythoe, the fire worm, which has white stinging bristles. Obviously it should not be touched.

CRUSTACEANS

Phylum Arthropoda

Class Crustacea

Most of our larger marine arthropods are in this class and over 600 species have been recorded from Hawaii. Crustaceans are protected by a jointed external covering called an exoskeleton made of chiton and lime. The exoskeleton is divided into three parts: the head, thorax, and abdomen. The head and thorax of many species are fused ond this covering is called a carapace. In order to grow larger crustaceans must molt (shed) their exoskeletons and grow new ones. First, the crustacean resorbs most of the exoskeleton into its blood and tissues by special processes. Then it splits and crawls out of its weakened covering. A new soft skeleton is already formed beneath the cast off skeleton. The crustacean takes in water which pumps up the new skeleton and gives the

animal room to grow. While the skeleton is soft the crustacean hids since it is vulnerable to predators.

Many crustaceans mate just after molting. A chemical released by the female just before she molts attracts the male to her. In some cases, when the female molts, the male will guard her while her new exoskeleton is reforming. Female crustaceans carry their eggs underneath their bodies and as the young larvae hatch, they flip them into the water with their abdomens. Young crustaceans do not resemble their parents and swim off into the ocean until they are ready to change into tiny crustaceans as we know them.

Many of the tiny crustaceans belong to the plankton community and are one of the main sources of food for fishes. These include ostracods, copepods and mysids. Others, isopods and amphipods live on the substrate. Larger crustaceans which are kept in the Aquarium are classified in the following way:

Class -- Crustacea

Sub-class -- Cirripeda (barnacles)

Sub-class -- Malacostraca

Order -- Stomatopoda (mantis shrimp)

Order -- Decopoda (5 pairs of legs)

Sub-order -- Natantia (shrimps)

Sub-order -- Reptantia

Tribe -- Macrura (lobsters)

Tribe -- Brachyura (crabs)

Tribe -- Anomura (hermit crabs)

BARNACLES

Sub-class Cirripedia

For many years barnacle shells were thought to be related to snails and mussels. Actually barnacles are relatives of shrimps and crabs. They begin life as small free-swimming shrimp-like creatures but when they find a suitable hard surface between the high and low tide marks, they attach themselves to it. Each species of barnacle is very particular about where it attaches for it must spend the rest of its life there. If young barnacles settle too high above the high tide line they dry out and die. If they attach themselves below the low water line they are usually eaten by predators. This is probably why most larvae settle on the scars of old barnacle shells rather than on new, clean surfaces.

After finding a suitable place to live, young barnacles place their heads on the substrate and cement themselves to it. After they are in place, barnacles then build their plate-like outer shells. When water covers them, their feathery legs may be seen kicking in and out of the tops of their shells, raking in fine food particles. When not covered by water, barnacles close their valve-like lids so that they do not dry out.

MANTIS SHRIMPS

Order Stomatopoda

Mantis shrimps are easily recognized by their round, stalked eyes and by their claws which have many prongs and operate like a jackknife rather than opening and closing like pincers. These are used to quickly stab their prey.

They are carnivores and actively chase their prey--small fish and invertebrates. Quite aggressive, they will kill each other, or slice an unsuspecting human

finger. Unless hunting, mantis shrimp hide in holes in rocks or in burrows which they excavate. Occasionally their independently movable eyes may be seen protruding from burrow openings. Mantis shrimp size and coloration is highly variable. Large mantis shrimp may reach 20 mm in length and are good to eat.

SHRIMPS

Sub-order Natantia

There are many different kinds of pelagic shrimp in Hawaii. At the Aquarium, we keep only those shrimp which can be found on the reef. During the day these shrimp usually hide in holes coming out at night to feed. They swim by means of paddle-like abdominal legs.

Saron, one of the largest and most numerous shrimp on the reef, is a nocturnal scavenger. The males have long striped legs, the female, shorter legs bearing tufts of hairs. The habits of this animal have still to be studied.

Snapping shrimp (Alpheus spp.) are so called because they have one large claw which is snapped if danger threatens or in social interactions. Pairs of these shrimp may be found excavating their burrows in the sand or in coral heads. The faint crackling sounds heard by divers are made by these snapping shrimp.

The red and white banded bandana (or barber pole) prawn (Stenopus hispidus) will eat most anything it can find on the reef. It will also clean fishes and tickle them with its large claws while picking off the fish's parasites with the tiny pincers on the first three pairs of legs. The red and white striped shrimp, Hippolysmata grabhami, also clean by leaping onto a fish and running up and down its sides picking off parasites. Fish recognize these shrimp and come to them to be cleaned.

Hymenocera picta, the delicate harlequin shrimp, is rare but can be found

from shallow to deep water. These shrimp inhabit coral and rock rubble and often carry a small seastar about as they feed on it. H. picta are usually found in pairs and it has been demonstrated that each shrimp is able to recognize its mate both visually and by smell.

A pair of shrimp always remain close together. When one shrimp begins to molt its mate covers it and wards off any animal which wanders near with its large claws. These claws, however, are relatively useless weapons made of a thin claw bone and a large flap of tissue; thus the generic name "Hymenocera". The specific name "picta" refers to the bright red colored patches on the shrimp's white body. As with all crustaceans, if a claw or leg is lost in battle the missing limb is regenerated under the external skeleton and appears again after the molt. Soon after the female molts she copulates with the male and becomes ladden with tiny red eggs which she releases in about 20 days.

The unique feeding behavior of these shrimp is noteworthy in that they eat seastars exclusively. In Hawaii one will usually find them feeding on the small, abundant Linkia sea stars, perhaps because this type of sea star is easier for the shrimp to turn upside down so that they can feed on it.

LOBSTERS

Tribe Macrura

We have three common lobster types in Hawaii. The spiny lobster, has no claws, may reach 40 cm in length and is most frequently caught for food. The Hawaiian lobster has claws but only grows to 1/4th the size of the spiny lobster. Hawaiian lobsters are red with white dots and live in holes. Their hairy claws can be seen protruding from these burrows, especially at night. Slipper lobsters may also reach

a length of 40 cm and are delicious to eat. These animals are flattened with short legs and no claws.

During the day the spiny and slipper lobsters hide in rocky crevices--the slipper lobsters often hang upside down on the tops of caves. During the night they scavenge for animal food--dead or alive. Like other lobsters, they swim backwards by repeatedly flexing their tails against their bodies. They do not have paddle-like abdominal legs for swimming.

Lobsters mate in the late summer. Immediately after the female molts, the male delivers his sperm to the female in a membranous package. The sperm package is retained by her in a special organ until the following summer. While laying her eggs, the female lies on her back and her eggs adhere to her feather-like abdominal legs. At this time, the sperm package is broken and the eggs fertilized. The female carries her eggs underneath her body for an additional year. Because of the mating and brooding behavior of these animals, it is illegal to catch lobsters during the summer months and female lobsters with eggs.

CRABS

Tribe Brachyura

Crabs are extremely common in Hawaii although they are not usually noticed because of their secretive habits. Most crabs hide in or under rocks and only emerge if they cannot find enough to eat in their hiding places.

When in the open, a crab scuttles from rock to rock and when alarmed, it usually stands high on its legs facing the object of alarm, stretches its clawed legs in an embracing position with it claws opened wide. When attacked, its clawed legs are moved toward its body and the pincers grab the attacker.

Swimming crabs (Family Portunidae), including the introduced Samoan crab, may become quite large and are sold in the market. The fifth pair of legs of swimming crabs are modified into paddles and are used effectively for swimming. These crabs live on sandy or muddy bottoms and actively chase their prey through the water.

In Hawaii there are over 100 species of pebble crabs (Family Xanthidae) and the number of individuals within this group are very numerous. These crabs live in crevices of the reef and have rounded carapaces. Most species have black-tipped claws which distinguish them from the white-tipped claws of the sponge crab. They mainly eat algae and small shellfish. Some of the largest pebble crabs such as the red convex and 7-11 crabs can be eaten.

Our most common sponge crab (Family Dromidae) is a large animal often found in deep water. It attaches sponges to its carapace. If sponges are not available, anything will do--styrofoam, wood, or even paper. Several other crabs decorate their carapaces. One crab carries anemones on its claws. Another group of crabs (Family Maiidae) have been given the name decorator crabs because they place seaweed on their backs. After having decorated themselves, these crabs look like bits of walking seaweed and cannot be easily detected.

The ugliest crabs are members of the Family Parthenopidae. These are poisonous to eat and were on ancient Hawaiian kapu lists. The bumpy body form of parthenoped crabs is unmistakable.

The box crabs (Family Calappidae) live in the sand. Their specialized claws, which are broader than long, close about their heads protecting their mouth parts. They have a specialized "tooth" on one claw which enables them to open a snail shell like a canopener. When buried in the sand, only their stalked eyes may be seen. When

sitting on the sand they look like white rocks. A crab that is not so well camouflaged and also lives in the sand is the Kona crab. In fact, this animal looks more like a lobster than a crab because its abdomen is not underneath its thorax. Kona crabs grow quite large and are delicious to eat.

Two types of crabs live out of water for long periods of time. These are the rock crabs (Family Grapsidae) and the ghost crabs (Family Ocypodidae). As their common names imply, rock crabs scuttle over the rocks searching for dead things to eat. Common in wave zones, their flat bodies are adapted for lying on rocks without being washed off by the surge. Ghost crabs are white and run along the sand at the tide marks looking for food. These crabs build permanent burrows in the sand and when danger threatens scuttle into them. Both kinds of crabs must wet their gills at least once a day or they will die. Like all large crustaceans, they cannot breathe air directly and must have a layer of water in their gill pouches in order that their gills may extract dissolved O_2.

There are several crabs which live in Pocillopora corals. These are the red, spotted trapezoid crabs and the gall crabs (Hapalocarcinus). Trapezoid crabs crawl amongst the coral branches whereas the female gall crab lives imprisoned in a coral gall. Both types of crab feed on material that collects in the coral--including some coral polyps and mucous.

HERMIT CRABS

Tribe Anomura

Hermit crabs carry their homes on their backs. Unlike the typical crabs that scamper on the rocks at the seashore, hermit crabs have soft abdomens and must find suitable protection. Most hermit crabs select mollusk shells in which to live. When they grow too large for the shell, they find larger shells and use them for their new homes.

If the larger shell is inhabited by another hermit crab, the crab desiring the shell attempts to and may succeed in pulling the shell's owner out. Different kinds of hermit crabs usually prefer varied shell shapes but if no shells are available, one can find them living in broken shells, worm tubes, and even in beer bottles. The number of shells for hermit crab homes thus limits the number of hermit crabs in an area. Crabs in imperfect shells or shells too small for their bodies are eaten by predators.

Hermit crabs are called generalized scavengers because they will eat almost any type of dead material on the sea floor. Like their relatives, the crabs and lobsters, they help clean up the environment. Our most common hermit crabs (Calcinus) are quite small and live under rocks during the day. Some hermit crabs (Dardanus) look for special sea anemones and place them on their shells. Since the anemones have stinging cells in their tentacles, they provide added protection for the crabs. For this service, the crabs carry the anemones about giving them a variety of environments in which to feed. Two animals living together in this fashion is quite common in the sea and the relationship is called mutualism because both animals benefit.

ECHINODERMS

Phylum Echinodermata

SEA STARS

Class Asteroidea

Like all echinoderms, sea stars are radially symmetrical. Their body parts are arranged in multiples of five; however, some species may have six arms or more. Many sea stars regenerate their arms easily and quickly (about one cm per week).

Sea stars, as well as sea urchins have a water vascular system--a series of

fluid-filled canals that aid in moving their tube feet. However, they lack the horny beak of the algae eating sea urchins. Instead, their stomachs can be everted from their bodies to digest their animal food externally. Sea stars are carnivores and prefer specific foods.

Acanthaster planci (the crown-of-thorns sea star) and Culcita novaeguinae (the cushion star) are fairly common in Hawaii and both eat corals. The crown-of-thorns is a large, multi-armed animal so named because its spiny projections are poisonous. It should not be handled without gloves. Serveral years ago, there was a crown-of-thorns sea star scare because large numbers of this species congregated on a coral reef off Molokai and devoured many of the corals. However, they disappeared or were killed and now pose little or no threat to Hawaiian coral reefs. Why they congregated in large numbers was never determined.

The cushion star's arms are folded over towards its mouth giving it the appearance of a 5 sided pillow. Often, the pearl fish lives in the gonads of this sea star and only emerges at night to seek a mate or to feed on small animals.

Two Linckia species are our most common sea stars. These small, multi-colored, long-armed invertebrates can regenerate even if a tip of one of their arms are left. Most other Hawaiian sea stars can regenerate only if part of their central disk is present.

Asterope and Pentaceraster species are not as common as Linckia. The former may be found in holes or under rubble on the reef, the latter occurs in pen shell beds. Both eat bivalves and look more like typical sea stars than our most common forms. Sea stars are not edible like their relatives the sea urchins and the sea cucumbers.

SEA CUCUMBERS

Class Holothuroidea

Sea cucumbers are also echinoderms. They have elongated, soft bodies and lie on their sides. They use rows of tube feet, located the length of their bodies, for clinging to objects. Sea cucumbers have a mouth which bears a series of fringed tentacles used in feeding. Feeding usually takes place at night and detrital material as well as sand are sucked up into the sea cucumber's mouth. Sand passes through the animal and the food particles are removed and digested. There are two distinct forms of common sea cucumber in Hawaii.

The loli (Holothuria and Stichopus spp.) are "hot dog" shaped with thick skins. They may be seen lying about on the reef or under rocks during the day. Those that are exposed are usually covered by a thin layer of sand. Sea cucumbers are capable of eviscerating their entire guts if alarmed but can regenerate them later. Some of these sea cucumbers have sticky filaments that they exude and which are very hard to remove from the skin. They are useful in trapping a predator crab by tangling it up. Picking them up can be very unpleasant but not harmful.

The second group of sea cucumbers are pink or black and white worm-like creatures. They are inhabitants of quite shallow water and tend to congregate in tidepools or in the alga, Acanthopora. Much food material collects in these areas and the sea cucumber feeds on it with its fringed tentacles. If you pick one of these creatures up, you will have two sensations. First, the animal seems to stick to your skin. This is because there are tiny spines and tube feet which anchor to your skin. Second, the animal slips through your hands since the water in it flows freely downward from one end to the other.

SERPENT STARS

Phylum Echinodermata

Class Ophiuroidea

Serpent stars are able to crawl more quickly over the substrate than sea stars. They do this by rapidly moving the many short spines on their five arms. The motion of each arm appears like that of a wriggling serpent. Serpent stars can break off their own arms the instant they are touched. The severed arm, still wiggling, is eaten by a predator while the serpent star escapes. No real harm is done, however, for the serpent star grows a new arm in a few weeks.

During the day serpent stars remain in crevices lest they be eaten. As many as 100 of these animals may crawl toward cover if the rock under which they are hiding is removed. They feed mostly at night and are able to catch their food in many different ways. They crawl after and catch large pieces of food with their arms. They are capable of leaping off the substrate into midwater to capture food particles. Some species can also spin mucous webs to entangle small particles, filter feed by spreading their arms and small particles become trapped on the spines, or absorb fine particles directly through their skin.

Most Hawaiian serpent stars are an inch long (disk to ray tip). Our most common form (Ophiocoma) is usually black and may be seen under almost any large rock.

SEA URCHINS, HEART URCHINS, SAND DOLLARS

Phylum Echinodermata

Class Echinoidea

Like its relatives the sea stars and serpent stars, the sea urchin's body is composed of five sections arranged radially from top to bottom. Its skeleton (called a

test) consists of many calcareous plates which are fused together. Internally are its digestive and reproductive systems and a special hydraulic system (the water vascular system) which operates its sucker-like tube feet. Water enters and leaves this system through a sieve plate and is pumped through channels in and out of the tube feet that the animal is using at the time. Its spines are attached to the test by muscles, and its tube feet protrude through tiny holes in the test. The sea urchin uses its tube feet for moving about in search of marine algae upon which it grazes. It feeds by rasping algae from rocks with its five-part calcareous beak. This beak is called "Aristotle's lantern" because it resembles a Grecian lantern, and was first described by the philosopher Aristotle.

Short spined sea urchins live in shallow rocky areas where their algal food is plentiful. There are three common species in Hawaii. The large purple urchin Tripneustes has the habit of picking up stones, shell, and bits of algae and placing them on top of its body. These objects are held fast by tiny pincer-like organs (called pedicellaria). The function of this behavior is not known, however, it is thought to camouflage the animal. Its rarer relative the white urchin, Pseudoboletia, completely buries itself in sand or rubble. Echinometra, the most common short spined species, is smaller than other short spined urchins. The green, pink, and black color forms of this species are now believed to be all one species. Echinometra lives in limestone cavities hollowed out by its spines. It does this by twisting and turning its spines to make cup shaped holes as it rasps off the algae in the area.

Long spined sea urchins or wana (Echinothrix and Diadema) have two types of long dark spines. The thinner ones contain poison but both can be painful. Although they have no eyes, long spined sea urchins are able to sense changes in water

movement as fish swim by and wave their spines rapidly in response. Two dark, slender animals, a fish and a shrimp, are adapted to living in these sea urchins. The shrimp crawls along the spines eating material collected on them while the fish lives between the spines, hovering in a head down position snapping at small invertebrates that pass by.

The red slate pencil urchin (Heterocentrotus) lives on coral reefs in shallow water. Its red color may give warning that it is not good to eat. Perhaps this is why the urchin has dull spines, not sharp ones.

In the splash zone lives a peculiar sea urchin known as Colobocentrotus. This urchin also feeds on algae. It is especially adapted for clinging to vertical surfaces in the splash zone--and is dorsoventrally flattened with modified short, broad spines.

Two other common urchins live among rubble. Eucidaris and its large relative Chondrocidaris have large thick spines which are often covered with protuberances. These brownish animals are fairly well camouflaged because their bodies and spines look like dead worm tubes or thin pieces of coral.

Heart urchins and sand dollars live in the sand. Their tube feet are lacking and the bottom of these animals are covered with movable spines used in gliding along or through the sand.

Most sea urchins are edible and are highly favored food items of several types of fishes. For example, triggerfishes and puffers, ignoring the spines, will pick an urchin up in its mouth and smash it on the rocks. Once it is broken, the triggerfishes and puffers devour the soft parts.

MOLLUSKS

Phylum Mollusca

Although collectors are primarily interested in the shell, the most biologically significant and fascinating part of a mollusk is the living animal within the shell. In fact, several very beautiful mollusks have no shell at all. All mollusks have a muscular foot, generally used for moving about, and a mantle. The nature of the foot (poda) distinguishes the major classes of mollusks. These are pelecypoda (keel foot), gastropoda (stomach foot), cephalopod (head foot), scaphopoda (trilobed foot), etc.

Mollusks are probably the most diverse of all phyla, varying in behavior from sessile filter feeders to highly active free swimming carnivores, and ranging in size from almost microscopic animals which feed on detritus to giant squid of over 30 meters long which are a fair match for the mighty sperm whale.

Mollusk species may have separate sexes or they may be hermaphroditic, while some such as Hipponix can change sex from male to female. Many shed their eggs and sperm into the water, but a few such as the cowrie and the octopus brood their eggs until they hatch. Some, like cones and murexes, enclose their eggs in capsules, and moon snails construct sandy whorled egg cases.

Most newly hatched mollusk larvae do not resemble their parents at all, but rather are tiny, free swimming members of the plankton community called veligers. Unlike most fishes, veligers are able to remain as juveniles until they find a suitable substrate on which to settle. When previously uncollected shell species are found in Hawaii, this does not necessarily mean that they have established a breeding colony here, rather it is thought that veligers born elsewhere were caught and remained in the currents for many months until they drifted to our islands.

In this section, the Classes Amphinura (chitons) and Scaphopoda (tooth shells) are not treated.

BIVALVES

Class Pelecypoda

Oysters, clams and scallops are bivalves--that is, their shell is in two parts rather than one. Like all mollusks, they possess a foot and a mantle.

Oysters cement themselves to hard substrates by either secreting a limey substance or byssal threads (tough horny fibers that look like horse hairs). They remain attached to the substrate throughout their lives filter-feeding by pumping water through their syphons. Oysters thrive in nutrient-rich waters like Pearl Harbor and South Kaneohe Bay. Unfortunately, these waters are polluted and even if oysters are washed in unpolluted water for several weeks, they may still harbor human disease organisms. The Hawaiian pearl oyster, one of our largest and most beautiful bivalves, lives in much cleaner water. This rare animal is on the endangered species list and cannot be collected.

Clams live in the sand or mud. A clam uses its foot to dig its burrow in the same fashion in which a piledriver operates. A clam filter feeds like the oyster, drawing nutrient-rich water into its incurrent siphon which is usually the only part visible above the sand. A clam can be usually located by collectors when its excurrent siphon pumps out the filtered water in a small jet. From time to time, clams can be collected in Kaneohe Bay. Before the "season" opens, these clams are tested for disease.

One of the most interesting Hawaiian marine communities is Pinna shells and the animals that use them as substrate, food and shelter. In deep water, sandy areas may contain beds of thousands of these bivalves. Many unusual animals such as the flame

wrasse and Pentaceraster sea stars live in the Pinna bed community.

Other bivalves include scallops, and "shipworms". Most of these are not encountered in Hawaiian waters unless one cracks open and turns over rocks.

The largest bivalve, the giant clam (Tridachna) is not found in Hawaiian waters. Elsewhere in the Pacific it may reach a length of over 1-1/2 meters, a weight of 250 kilograms, and can live for over 50 years.

SEA SNAILS, NUDIBRANCHS and SEA SLUGS

Class Gastropoda

Most sea snails have a single shell, however, sea slugs and nudibranchs (Subclass Ophisthobranchia) either have a tiny shell embedded in their tissues or loose their shell shortly after they emerge from the plankton. The foot of gastropods is muscular and used for crawling about or burrowing,and the mantle both polishes the shell (inside and outside) and contains breathing structures. Gastropods also have an operculum which fits across the opening of the shell and is used to protect the snails' soft parts.

After the veliger stage is passed, a coiled shell appears. The snail grows by producing shell material (calcium carbonate or lime) from glands at the edge of the mantle. Some gastropods such as cowries develop a radically different shell upon reaching maturity and stop growing. Others keep on growing and never modify their shells.

Most gastropod mollusks feed by means of a radular ribbon of many hard small teeth. Herbivorous snails use the radula to scrape algae from rocks. Several families of gastropods use these teeth to drill holes in other mollusks. The most highly modified radular teeth belong to the carnivorous cone shells.

Our largest Hawaiian gastropod is the helmet shell (.5 meters long) and

our smallest, a tiny micromollusk about 2 millimeters long. The life span of most gastropods is unknown.

SUBCLASS PROSOBRANCHIA

Mollusks which undergo torsion, bringing the gills in front of the heart.

LIMPETS

Family Patellidae

Although limpets (opihi) bear little resemblance to other common marine snails, they are an important and fascinating part of the Hawaiian gastropod community.

Their shells are simple cap-shaped shields with nothing much to recommend them as items of beauty. But this shell form is most efficient in sustaining the life of the animal. It provides maximum suction area needed for clinging to the smooth surface of rocks on surf-swept coastal areas. It serves as a water storage tank and windshield, thereby protecting the animals from desiccation and affords a low profile against wave stress.

The development of the shell is interesting in that the first shell, which appears when the veliger is about two days old, is dextrally coiled and complete with operculum. When the animal is about three weeks old, the operculum is lost, and the cap-shaped shell begins to replace the coiled veliger shell.

Opihi feed on minute algae species. By moving their heads from side to side, they use the long radular ribbon much like one would use a scythe to harvest wheat. Some animals travel one to two meters while grazing and have been observed returning to their "home" station on the rock.

Most limpets are nocturnal feeders and spend their daylight hours clamped tightly to a rock or other smooth substrate. Two species most commonly found in Hawaiian

waters are the black limpet and the talc limpet. Both are edible, and being "too tasty for their own good", are becoming difficult to find.

WORM SNAILS

Family Vermetidae

Worm snails begin constructing their shells in the typical form of other mollusks--tightly coiled spires--and cement themselves to rocks or other forms of hard substrate. As soon as a few turns of the shell are constructed, worm snails appear to "give up" and their tube-like shells are built in various directions along the surface of objects. Worm snails spin mucous nets to catch their food.

VIOLET SNAILS

Family Janthinidae

Some of the ocean's strangest snails are the delicate purple janthinids which drift near the surface suspended by a number of bubble-like chambers. Janthinids are adept at engulfing their food, the Portugese man-of-war, with their long prehensile mouths and are immune to the stinging tentacles of their host. In Hawaii violet snails are found washed up on our beaches after storms together with the Portugese man-of-war.

CONE SHELLS

Family Conidae

Some of the most interesting and beautiful members of the Hawaiian marine gastropod community are to be found in the Genus Conus. Some authorities say there are about 400 species in the family, others say 600, and still others tally over 1,000 named species. However that may be, 45 species have been reported from our waters, and at least two are considered endemic.

Being predators, cones are equipped with a radular modification suitable

for capturing and narcotising prey. Instead of the many-toothed ribbons of most gastropods, Conus has harpoon-like teeth which make it possible to spear and paralyze small animals. Some species are cannibals; others eat worms, fishes and other mollusks.

As a link in the food chain, cones are preyed upon by some fishes, tritons, other cones, crabs, and sea stars. Many juvenile shells have been found with neat round holes drilled through the crown or body whorl--the unmistakable signature of some boring mollusk.

The range in size among species in our waters is from the less than 2 centimeters long Conus sponsalis to the giant 20 centimeters Conus leopardus.

According to species, cones decorate their shells with colorful tents, checks, dots, wavy lines or blotches and sculpture, which includes beading, grooves, vertical and radial striations and sometimes pronounced sutures--but there seems to be no reason for this intricate adorning. Whatever the reason, it is apparently not for camouflage, because all the design and color is covered by a protective, unusually unattractive overcoat called the periostracum. On some species, it is thick, on others thin. Some are fuzzy, some smooth. In most instances, it hides the beauty of the shell. One wonders then, why the mantle is equipped to layer on decoration. In the Cone Kingdom, is beauty its own reason for being? Or is there a more utilitarian reason?

Although Conus is not considered an aggressive animal, the genus bears a reputation as dangerous and sometimes deadly. The same apparatus which enables it to paralyze its prey can inflict serious wound on careless collectors. There are numerous documented cases of fatalities from the sting of each of several members of the genus and many more cases of severe pain, paralysis and near death. At least 12 species are on the known to be dangerous list. Eight of these are found in Hawaiian waters, a[illegible] other species

are suspect. A word to the wise--Handling Live Conidae May Be Hazardous To Your Health!

Cone shells are exceedingly numerous in Hawaii. After they die they are often washed ashore and ground down, especially on beaches where the waves continually stir up the sand. Usually the apical (top) end remains and the columella (point of attachment for the shell whorls) breaks leaving a puka--hence puka shells are formed. Puka shells may be formed from a number of other mollusk shells but those from tiny cone shells fetch the highest prices.

TRITONS

Family Cymatiidae

Approximately 20 species of this family have been recorded from Hawaiian waters, and at least two are considered endemic. Distinguished as the world's second largest known gastropod, Charonia tritonis (triton's trumpet) is certainly our most spectacular shell. The animal which secretes it is not less fascinating.

In about six years time, this gastropod progresses from a microscopic, free-swimming larva to a magnificently shelled specimen up to .5 meters in length. It is predacious on a number of sea star species, among them the infamous reef ruiner, crown-of-thorns. All members of the family are believed to be carnivorous, consuming simple ascidians (sea squirts) and mollusks.

The shells of these animals have been used for centuries in a variety of ways by people of eastern and southern Pacific islands. In various cultures they have served as lamps, cooking pots, drinking vessels, ceremonial and ritual vessels and trumpets. Trumpeting through the broken spire is still a part of religious rites and other celebrations on Polynesian islands.

Unfortunately, its size and beauty has made it difficult for the animal to survive in shallow waters where it can be observed in its natural habitat. Evidence points to the probability that it is preyed upon by octopi, crabs, some species of fishes, and human predators as well. Throughout its range, it is not commonly seen, and some countries have recently taken measures to protect the species from collectors.

It has been suggested that the large, red hermit crab, Dardanus punctulatus, may literally eat Charonia out of house and home before acquiring the shell. However, it is most generally believed that the hermit simply moves into a deserted shell. In any case, he is often seen jauntily dressed in the remains of Hawaii's largest gastropod.

PERIWINKLES AND NERITES

Families Littorinidae and Neritidae

One commonly encounters small grey periwinkles (pupu) and black nerites (pipipi) in the intertidal zone of Hawaii. The animals clump together in small groups during low tide and crawl about at high tide rasping algae from the wave splashed rocks.

Hawaiians collected, boiled, and ate periwinkles, removing them from their shells with a stick or with their fingers. Perhaps this is why the Hawaiian name for these small mollusks, pupu, was adopted for hors d'oevres by the haole.

AUGERS and CERITHIUMS

Families Teribridae and Cerithiidae

All members of these two groups live under the sand and eat tiny worms and other small animals that they encounter as they plow along. They are nocturnal feeders but their tracks may be seen during the day and shell collectors find them by fanning away the sand at either end of these grooves.

Augers are heavy bodied, long spired shells. They are beautifully pattern-

ed shells, eagerly sought by shell collectors. Some such as Terebra maculata may reach 30 centimeters in length whereas others are mature at 10 millimeters in length. Augers live in many different sandy habitats, some where the waves break and others at depths of over 70 meters.

COWRIES

Family Cypraeidae

The glossy coverings of cowries are carefully polished and maintained by the inner mantle layer when it is raised. Only the shells of old or sick cowries develop whitish discoloration and become encrusted with fouling organisms. Because of their beauty and high gloss, they are collected and made into leis and other decorative objects by Pacific islanders. The two cowries most commonly fashioned into art objects are the yellow Cypraea annularis which does not occur here, and the money cowrie C. moneta which is rare in Hawaii. Six of the 32 cowries found in Hawaii are endemic, and highly prized by collectors.

Cowries live in holes or under rocks on the reef usually near their food. At night they venture forth to browse on sponges, corals, and algae.

The tiger cowrie (C. tigris) is the largest member of the family in Hawaii and grows to a length of over 15 centimeters. It occurs throughout the Pacific but achieves its largest size in our islands. Tiger cowries were eaten by early Hawaiians and their shells used as octopus lures. The mantles of most cowries are colored to camouflage the animal from predators. C. gaskoini, C. teres, and C. chinensis all have bright red mantles and closely resemble the red sponges among which they live and probably feed upon. Others such as C. cicercula resemble yellow sponges, while some, like C. isabella, can easily pass for a small black sponge. A puzzling exception is the rare and

endemic C. tessellata, distinctive "checkerboard" pattern shows up clearly through its transparent pale yellow mantle. The snakehead (C. caputserpentis) and mauritius (C. mauritiana) cowries are common and inhabit the surge zone. Cypraea granulata is a pink-brown endemic shell often used as the clasp for strings of the tiny sand dwelling Columbella shells which are collected on Niihau and strung into leis.

ROCK SHELLS

Family Muricidae

Rock shells are predators on small worms and mollusks. In Hawaii we have several different forms with interesting habits. The most highly ornamented of these is the worm-eating Murex pele which may be found on rocks and is garbed in a variety of colors. Other representatives are the drupes and morulas. These animals live on subtidal rocks and use their radular teeth to drill small holes into the shells of other mollusks. Most of the dead shells found with small round holes in them have been eaten by rock shells.

HELMETS

Family Cassidae

There are several small and one large species of helmet shells in Hawaii. Our largest helmet, Cassis cornuta reaches a length of about 30 cm. It lives in sandy deepwater areas and eats heart urchins and starfishes. This helmet is used by the Polynesians as a musical instrument along with triton's trumpet.

TUNS

Family Tonnidae

Tun shells are nocturnally active sand and rubble dwelling mollusks which feed on sea cucumbers. These animals have an enormous foot enabling them to glide over

the sand with ease. It is a wonder that the animal can stuff this foot back into its shell when it closes up. Our largest shallow water tun, Tonna perdix is rarely encountered, however its shell is frequently seen, inhabited by a large hermit crab.

MOON SNAILS

Family Natacidae

Moon snails also have an enormous foot which they use to glide over and through the sand. These snails use their radulas to drill into shells and digest the animals inside. Moon snails have glossy rounded shells and construct spiral sandy cases for their eggs.

OLIVE SHELLS

Family Olividae

Olive shells are similar to moon snails. They have a large foot, a polished shell which resembles olive pits in shape, and are sand dwellers. They are carnivores and engulf anything small that they can catch.

BASKET SHELLS

Family Nassaridae

Basket shells live under rubble, in sand, or in holes on the reef. Their siphon is usually exposed and can sense dead or dying animals very quickly. Once food is located this mollusk literally erupts from its hiding place, grabs the animal, covers it with its foot and pulls it under the sand to eat it at leisure. When food is placed in an aquarium the basket shell will hold its own against a crab or lobster.

MITERS

Family Mitridae

Miters are elongate gastropods with varying habits. Some live in coral,

others in rubble, and the larger ones live in sand. They are carnivores and feed on worms and other small invertebrates. Miter shells are beautifully structured and patterned and are a favorite of shell collectors.

STROMBS

Family Strombidae

Although strombs are small and rare in Hawaii their interesting habits and attractive shells make them noteworthy. They are algae feeders and actively move over the reef in search of plant food. Strombs have well developed eyes which are the first parts of the body to emerge from the closed shell. They also have a sickle-shaped operculum used as a trap door to protect the animal inside. If picked up, strombs flip the operculum backward and foreward and can cut the hand of a careless shell collector. The largest stromb, Lambis lambis does not occur here but is common elsewhere in the Pacific. Adults have a number of large spines projecting from the lips of their shells. Juvenile strombs lack these projections and thickened outer shell lips.

PARASITIC SNAILS

Family Eulimidae

All these snails are parasitic. The most common member of the family is Balcis which lives on sea cucumbers. This small white snail eats the mucous and fecal material from its host and apparently does it no harm. Examination of any of the large, black sea cucumbers in Hawaii usually will reveal one or two Balcis clamped tightly to their skin.

SUBCLASS OPISTHOBRANCHIA

Nudibranchs, sea slugs and bubble shells belong to this group of mollusks.

All have shells which have either been reduced or lost and their gills are in back of their hearts.

Nudibranchs are colorful delicate creatures which may be seen gliding about on coral reefs. There are three main types.

The backs of eolid nudibranchs are covered with long projections which are extensions of their stomachs and also their gills. They eat corals and store unfired nematocysts in their bodies for defense against predators. Most eolids match their food in color. Among the most beautiful eolids are Phestilla melanobrachia which feeds on Tubastrea aurea (see Camouflage), and the golden brown P. sibogae which nibbles on Porites polyps.

The gills of sacoglossan nudibranchs are not visible. These animals suck juices from algae and store chloroplasts in their bodies. Chloroplasts are small bodies in plant tissue which produce sugar during photosynthesis by using CO_2, H_2O, and sunlight. The chloroplasts in sacoglossids continue to function and produce food energy for the animals. Therefore, sacoglossans like Pleurobranchus when kept in the dark without food, live only half as long as their starved cousins living in sunlight.

Each dorid nudibranch has feather-like round structures on its back called a respiratory tree. Dorids eat tunicates and sponges and all can swim by undulating their foot. The largest dorid in Hawaii is the spanish dancer, a large, red animal. On this unusual nudibranch are often a pair of tiny red shrimp which live off its mucous. Dorid nudibranchs often liberate toxin into the water when alarmed and do not make good aquarium pets.

Sea slugs are related to nudibranchs. They are usually dull brown in color and eat algae. Our most common form Aplysia eats sea lettuce (ulva) but again

is not a good aquarium animal because it is forever laying sticky strings of eggs which clog the filters, pipes and everything else for that matter.

Bubble shells are also ophistobranchs although they have a very delicate but entire shell. These animals are carnivores and feed on small worms and shells. The enormous foot of a bubble shell allows it to glide smoothly over and through the sand under which it lives.

SUBCLASS PULMONATA

HAWAIIAN FALSE LIMPETS

Family Siphonaridae

Many beach prowlers find small limpet-like shells along the high tide line or on rocks in the lower tidal regions and think they are small black limpets. More than likely, what they have found is Siphonaria normalis. Although the shells are very similar, the animals are quite different. Other gastropods have only gills through which they extract dissolved oxygen from the water. The false limpet has both gills and lungs and is related to land snails. This double feature enables it to live in or out of water for long periods of time. For the most part, they divide their time between the tide limits and are considered by some authorities to be a link between the aquatic and terrestial. However interesting their development, they are bitter and you may be sure the Hawaiians do not confuse them with opihi.

OCTOPUS, SQUID and NAUTILUS

Class Cephalopoda

Unlike many other mollusks cephalopods have well developed eyes and in octopods at least, the shell is completely lacking. Their mantle is tough and muscular.

Octopods have eight large prehensile tentacles with suckers for attaching or capturing prey. They have the ability to regrow a new arm when on is lost. The mouth, at the center of the radiating arms, is provided with powerful horny jaws, somewhat like the beak of a parrot.

Octopods are usually found in holes, even man-made ones. For example, Captain Jacques Y. Cousteau, while exploring an ancient Greek ship, found hundreds of amphorae (jugs) and most contained an octopus. The octopus can crawl in and out of unusually small openings and must be sealed into an aquarium if kept in captivity. It usually crawls along the bottom but, if alarmed, it swims by filling the mantle cavity up with water, then compressing it and shooting the water out through a funnel or syphon which propels the animal along. The funnels are very mobile and can be directed anteriorly or posteriorly for forward or backward movement. The rapidity of movement depends on the force with which water is expelled from the funnel.

Octopods are famous for rapid color changes which permit them to blend into nearly any surrounding, to conceal themselves from prey and predators. They are preyed upon by large carnivores. The unusual coloration of octopods is caused by the presence of chromatophores or pigment cells located just beneath the skin. Thousands of chromatophores are distributed throughout the skin of the octopus. These cells are small, transparent elastic sacs containing pigments. The size of these color cells can be changed at will by the animal. Around the sac, radiating outward like wheel spokes, are microscopic strand muscles. When these muscles are relaxed, the chromatophore sac becomes small, and the pigment does not show. At this point if you were observing the octopus, it would be a gray-white color. The pigment cells only show as small dark pin point marks against a layer of underlying gray-white skin cells. Conversely,

as the strand muscles contract, the chromatophore sac is pulled outward in all directions, stretching it larger and exposing the pigment. Color changes are controlled by the nervous system. Thus the octopus can camouflage itself by assuming the color and texture of sand or rocks. The octopus' principal defense is its ink sac which it discharges when alarmed or attacked. The thick blackish or brownish fluid is stored in a small pear-shaped reservoir called the ink sac. When the animal is alarmed, the ink is released through the anus and the cloud of inky water confuses the predator and temporarily deadens the enemy's sense of smell. The octopus can then swim or crawl away or as a last resort use its horny beak for biting.

The male octopods have one arm which has become modified as a sex organ, called hectocotylus. After finding a suitable mate and caressing her with his tentacles, he inserts the hectocotylus into her mantle cavity. The sperm cells then travel down this arm and into her oviduct. Mating may go on for as long as 24 hours.

When the female is about to spawn she seeks out a sheltered rock, hole or a similar hideout to deposit her eggs. The eggs are laid in bunches attached to thin stalks. Female octopods remain to care for the eggs after they are deposited. The mother continually cleans the eggs by gently caressing them with her arms and shoots water at them from her funnel. This is to protect the eggs from injury and keep them free from parasites. She also defends them from being devoured by their own father. Most female octopods reject any kind of food while caring for the eggs, and when the young hatch three to four months later, the females die. Newly hatched octopods are carried in the currents for the first few months, then settle on the bottom.

In Hawaii we have two common shallow water octopods called he'e or squid, the long armed Polypus ornatus (night "squid"), and P. marmoratus (day "squid").

These animals are usually found in holes on the reef.

True squid (muhe'e) are less common in Hawaiian shallow waters than octopods. Occasionally small groups will be seen floating near the surface. The squid has ten tentacles and can readily change color but usually turn whitish, bluish, or greenish to match their midwater backgrounds. Squids have large eyes like the octopus and use them to spot their prey, larger planktonic animals. They also can see predators from long distances away and swim away rapidly. Squid can only be successfully kept in circular aquaria because they swim backwards and repeatedly bump their tails into the glass, damaging themselves. Their mating habits are similar to the octopus.

The chambered nautilus is related to octopods and squids. It's shell is imported from the Indo-Pacific for sale here. The "paper nautilus shell" is sometimes found on our beaches. It is in reality the egg case of a small pelagic octopus (Argonauta) which secretes it with two specialized flap-like tentacles.

ELASMOBRANCH FISHES

Sharks and rays are easily distinguished from other fishes by five or more gill slits and by their upturned tails. Internally, sharks and rays have a cartilaginous skeleton. Their skins are tough and sandpapery in texture and their teeth are replaced as they fall out. Modern sharks differ very little from prehistoric sharks preserved in fossil beds, whereas other fishes have evolved in many different ways and most do not look like their primative ancestors.

Rays

Rays are dorsoventrally flattened elasmobranchs with long whip-like tails. Their pelvic and pectoral fins are large, often fused, and used for swimming. Some rays have barbs at the base of their tails and are called stingrays or eagle rays. Sting rays and eagle rays eat crabs and shellfish. Stingrays spend most of their time buried in the sand. In Hawaii they are not common, very shy, and try to avoid swimmers. If stepped upon, however, they lash their tails over their bodies to stab the "attacker". Other rays like the manta ray are huge animals with flange-like mouths used for gathering plankton.

Sharks

The fearsome shark is the most exciting topic discussed by divers. Ancient Hawaiians also feared the shark and told legends about sharks called mano kanaka, the supposed offspring of a human mother and shark father. These sharks were considered as a personal god or aumakua to the family to whom it was mythically related. This belief was made possible partly because some sharks such as the white tip (Triaenodon) and the reef sharks (Carcharhinus) are territorial and can be repeatedly seen in the same area. The natives would feed their shark god for luck before a fishing trip.

The white tip is often found in caves during the day. It is our only reef

shark which can lie on the bottom and pass enough water containing dissolved oxygen through its gills to breathe. Other Hawaiian sharks, especially the large specimens, cannot be kept in our aquarium because they must continually swim to breathe. These sharks are kept in large circular tanks like the one at Sea Life Park.

One of the characteristic behaviors of a sufficiently provoked grey reef shark is its defensive posture just preceeding an attack. It lowers its pectorals and does a peculiar dance. (See Johnson & Nelson, Copeia, 1973 (1) 76). The sand bar shark is the elasmobranch most commonly seen in Hawaii. It is less territorial than the grey reef shark and will not often display to divers. It frequently approaches people in the water but will not bother them unless they are spearing fishes.

Sharks feed on reef fishes and other large invertebrates such as squid and crab. Sharks and many other large predators become most active at sunrise and sunset. This is the period when the night and day fishes are exchanging places and a majority of animals are exposed on the reef. Amongst the confusion of establishing territories and occupying sleeping holes, predators take advantage and feed. Other large predators active at this time include ulua, snappers, groupers and eels.

Hammerhead sharks are common in our bays during pupping time. Like the reef sharks, they give birth to live young in shallow water. They do not eat for some weeks prior to pupping and after delivering their young are very hungry. In fact, most newly born hammerhead sharks are eaten by their mothers. Although most fishes which do not care for their young will eat their own offspring if they can catch them, other kinds of fishes readily eat their young too. Hammerhead shark adults, however, seem to be the only predator of young hammerheads.

SEA TURTLES

Most of the world's sea turtle populations are experiencing significant declines due to overexploitation and/or habitat destruction. If adequate protective measures are not taken in the near future, many of these populations will become extinct.

For centuries sea turltes have played an important role in the diets of native peoples that inhabit tropical regions. Unfortunately, commercial demands for exotic wildlife products in the more affluent countries have altered the traditional usage of sea turtles. This has resulted in increased hunting pressures. High prices paid for derived products such as steak, calipee (belly cartilage for soup), oil (for cosmetics) and shell offer a strong incentive for fishermen to kill as many turtles as possible. Along with this factor, ancestral nesting beaches and coastal feeding pastures are being adversely affected by land development and growing human populations.

Although there are eight different kinds of sea turtles, only two are native to Hawaii, the green turtle (honu) and the hawksbill ('ea). A third turtle, the leatherback, has no Hawaiian name and only occasionally visits local waters. This rare species primarily inhabits the open ocean and does not nest in the island chain. The Hawaiian hawksbill population presently consists of very few individuals. Only single nestings on the islands of Molokai and Hawaii have been recorded in recent years. Both the hawksbill and the leatherback are officially listed as being endangered with extinction; full protection is provided by the United States government.

The green turtle is the only species that still occurs in any numbers in Hawaii. Declines have also taken place in this population. Although green turtles formerly laid eggs on beaches of the major inhabited islands, the only remaining breeding

site is French Frigate Shoals. This reef area contains several small sand islands and is located 480 miles northwest of Honolulu in the Hawaiian Islands National Wildlife Refuge. Adults (20 pounds or more) migrate to French Frigate Shoals approximately once every three years and nest between May and August. The method of navigation used for these long-distance travels is unknown. Recent studies at French Frigate Shoals have indicated that fewer than 200 females are present during each season. The greater portion of the Hawaiian green turtles life cycle is spent in shallow coastal waters feeding on marine vegetation (benthic algae). Numerous important feeding pastures exist around the major island as well as in the northwestern portion of the island chain. In 1974 the State of Hawaii made it illegal to capture green turtles for commercial purposes. However, some harvesting for home usage is still permitted.

Reproduction and care of young presents a special dilema for the sea turtle. Being air-breathing ocean-living, egg-layers, they must find a safe, non-aquadic location that is near ocean water. The eggs are laid in beach sand because their outside membranes are semi-permable to allow oxygen exchange. Were the eggs laid in the sea, the unhatched young would suffocate. The female selects an area far from the water's edge, just before the sand meets the ground cover. She lays about four clutches averaging 100 eggs each during her three month nesting task. During the egg laying process, which may take several hours, egg eating predators take their toll. Once the eggs are covered with about 3 feet of sand, they are safe for the 60 day hatching period.

After the young have hatched, in a joint effort they dig their way toward the surface. Young turtles are vulnerable to predation as they surface and seek the ocean immediately. Once a turtle becomes mature it has no successful predators other than man.

Three kinds of sea turtles are in this aquarium.

The hawksbill is distinguished by three characteristics: a) a pointed "hawk-like" beak, b) two pairs of head plates between the eyes, c) carapace plates which overlap at the back. The loggerhead can be identified by its considerably larger head as compared to other turtles. The remainder of the animals are green sea turtles. The name is derived from the color of the fat found inside the body, not from the shell or skin color. Green turtles vary greatly in coloration. To identify a green turtle see if there is one pair of plates between the eyes.

All adult male sea turtles have long thick tails that extend past the hind limbs, while the adult female has a very short tail. Sea surtles are highly adapted for the marine environment with a streamlined body and modified flipper-like limbs. Although slow onlandwhile nesting, they are rapid and graceful in water and can stay submerged, under certain conditions, for up to two hours.

For additional information on the biology of sea turtles as well as the survival problems that are being encountered, refer to: "Great Reptiles, Great Enigmas" by Dr. Archie Carr, AUDUBON MAGAZINE, March, 1972.

HAWAIIAN MONK SEAL

The existance of monk seals in the Leeward Island was recorded by hunting expeditions in 1838 to 1857. Seals were located on Kure Island some two hundred and forty miles northwest of Kauai in August of 1859. When the Polynesian, an early publication, reported that the hunting ship "Gambia" returned from the Leeward Islands with two hundred and forty barrels of oil and one thousand five hundred seal skins, the beginning of the decline of the Hawaiian monk seal was recorded.

Scientists took notice of the monk seal when in 1890 the first photograph of them was taken on Laysan Island. In 1905 Mr. Matschie based a type species descrip-

tion on a seal skull given him by Mr. Schauinsland, who had visited Laysan Island in 1896. The scientific name thus derived for the Hawaiian monk seal was Monachus schauinslandi, Matschie. A detailed record of the seal population was begun only in 1959. This record was based on available reports from 1914 to 1956. In 1960, there were an estimated 1,350 seals still alive in the Hawaiian Islands--a dangerously low population density.

Fortunately, scientists and legislators helped to enact measures prohibiting the hunting or capturing of these seals. Today, the majority of animals live on islands of the Leeward chain.

Monk seals when observed, exhibit a natural curiosity. They are quite tame and friendly unless harassed. In hopes of discouraging a molesting human, the seal will dive and swim away or they may lunge at the observer and can bite severely. Males appear to be fussy about mate selection. They do not assemble harems like harbor seals, but rather mate monogamously. It is not known whether this alliance lasts for life.

New born pups are colored shiny black, and later, at 20 to 60 days, the fur sheds, and a rich chocolate brown coat appears. After birth the seal pup quadruples his birth weight reaching 35 pounds in the first month. The nursing mother fasts for the first few months and may lose as much as 200 pounds. Mother monk seals are extremely attentive, constantly watching for possible danger, and keeping vocal contact with the young seal at all times. If forced to fight to defend her pup, she will station the pup under her chin, making sure her body is between it and the intruder. The mother weans her 130 to 150 pound pup at the end of the first year. After weaning the pup finds life difficult. Unable to effectively find food, the yearling will sustain himself on his baby

fat trimming down to approximately 100 pounds. As the seal matures, it's interest in food becomes more acute, and it becomes a nocturnal bottom feeder. The seal's diet may consist of fish and octopus. Maturity is marked when the rich chocolate coat molts to a dull brownish or yellow coat.

Friday has been in captivity at the Waikiki Aquarium for twelve years. He arrived as a young pup on December 13, 1963 from the French Frigate Shoals. He weights about 350 pounds. His diet includes fresh frozen smelt, herring and aku. He prefers aku, but receives it on special occasions only, for that fish is expensive. He consumes on the average of 12-1/2 pounds of fish per day, or about six pounds per feeding.

When observing Friday, you'll soon notice his peculiar habit of turning circles in the water. This behavior is only found among monk seals, and is thought to be part of their courting display. Friday has adapted this courting behavior into begging for food, and pirouettes for his dinner. The Aquarium recently received permission from the Department of Land and Natural Resources to seek a mate for Friday, so perhaps someday he will not pirouette for food.

FEEDING THE AQUARIUM'S SEALS, SHARKS AND TURTLES, 1975

The Aquarium must spend approximately $8,000 to $10,000 annually to feed the animals. Most of the money is spent on the seals, sharks and turtles, in that order.

The seals feed on fresh frozen smelt and herring. They prefer fresh aku, but it costs thirty to forty cents per pound, as compared to seventeen cents for smelt and herring. Friday consumes the most fishes, about fourteen pounds per day. The harbor seals eat eight or nine pounds daily. They are fed at 11:45 a.m. and 2:30 p.m. daily.

Our sharks are fortunate because they are fed aku. Smelt and herring are oily fish which foul the shark tank.

Turtles dine on squid and algae. The squid costs about fifteen cents a pound. Approximately ten pounds of squid are consumed daily by the turtles. The algae they prefer is sargassum which is collected by the aquarists when they have time.

LIMU -- THE PLANTS OF THE REEF

Seaweeds, most of which are known in Hawaiian as limu, are the commonest and most obvious plants on our coral reefs. They belong to a group of plants known as algae. Like their terrestrial relatives, they require light and nutrients for growth. However, unlike land plants, limu derive their nutrients from the surrounding water, rather than through roots from the soil.

Seaweeds are divided into three phyla largely on the basis of their pigments and their color. There are the brown algae or Phaeophyta, the red algae or Rhodophyta, and the green algae or Chlorophyta. Within each of the three phyla the actual color of the plants may vary widely.

There are three common growth habits among the attached algae of the reef. The first is a fleshy erect form which may range in size from a fur-like growth on rocks to the meter-sized brown alga Sargassum (limu kala-lau-nunui) or the green alga Dictyospaeria (limu lipuupuu). This growth form occurs in all three phyla. The second growth form is erect and calcified (limy). The skeletons of these limu contribute to sand and mud when they die. The erect calcified forms occur in all three phyla; the commonest being the brown Padina (limu pepe-iao), the red Jania (limu huluilio), and the green Halimeda (limu ekaha). The third growth form is calcified and encrusting. These exclusively red algae, commonly of the Genus Porolithon, cement and bind the reef together; contributing to its wave resistance. Encrusting algae were not called limu by the Hawaiians, probably because they were not known to be plants.

Most land plants which reproduce with flowers which contain pollen and seeds called male and female gametes. Marine algae can reproduce by the production of spores, which are single cells capable of producing a new plant without fertilization and

by gametes.

The distribution of algae on the reef is controlled by three major factors: 1) light--they grow to a maximum depth of about 60 meters; 2) substrate--some attach to hard bottoms while others prefer sand or mud; 3) wave energy--some attach firmly and can resist moderate wave attack while others require quiet water. In many exposed areas there are seasonal changes in algal populations largely as a result of seasonal storms.

In addition to forming sediment and cementing the reef, marine algae serve other functions on the reef. Many of the algae provide food for fish and invertebrates. In addition the larger algae serve as shelter for many reef organisms.

Limu is also used by man. Many of the red, and some of the brown algae are eaten raw, cooked, or dried. They are also used as glue, gelatine, and to thicken soups and gravies. The common edible limu are Gracillaria (limu manauea), Enteromorpha (limu 'ele 'ele), Dictyopteris (limu lipoa), Codium (limu wawae 'iole), Ulva (limu palahalaha), and Asparagopsis (limu kohu). Limu is also used as fertilizer in that it is rich in nitrogren and potassium. The commonest limu used for fertilizer is Sargassum (limu kala-lau-nunui).

SAMPLE BASKET LECTURE

The objects to be used are at the Docent's descression. As you realize, the children's short attention span will probably limit the number of specimens you will be able to discuss. Tune in to the children, plan which specimens you will discuss, and be ready to add or subtract from your talk.

All animals need to protect themselves from their enemies. A dog has sharp teeth, a cat has claws and can climb to high places to escape his enemies. Now I will show you how marine animals protect themselves.

When a big fish chases the spiny puffer it can blow itself up by gulping water. As it gets fatter with its spines sticking out, the animals who might want to swallow it can't. You'll see a spiny puffer in the aquarium but it won't be blown up and its spines will lay flat against its body.

These jaws and teeth belong to what animals? (shark) How do you think a shark protects itself? (usually answer teeth) Yes, the shark has several rows of sharp teeth growing one behind the other. It's lucky, because when a tooth in the front row is lost a tooth from the row behind replaces it. The shark never has to go to the dentist. Sharks have another means of protection, they have very rough skin. (Pass skin sample around after the lecture and ask what does it feel like? [sandpaper]).

Take out scorpionfish. What is this? This fish is called a nohu here in Hawaii. Scientists call it a scorpionfish. Can you think why? It has poisonous stinging spines in its fins. These spines protect the scorpionfish from enemies. The meat is good to eat, just be careful when you are preparing it to eat.

Review: We have seen how this fish protects itself (puffer), do you remember? How does the shark protect itself? (jaw)

Now, this animal (cowrie shell) protects itself in a way we haven't talked about, can you guess? It hides in its hard shell. Do you know the name of the shell? (cowrie) A soft animal, much like the slugs you see in your gardens lives inside. Here is another soft bodied animal (triton). It grows the largest shell found in Hawaii. These triton's trumpets are becoming hard to find because people are taking them out of the ocean. They are so beautiful, people like to decorate their homes with them. If we keep taking triton's trumpets from the ocean, we will soon find there are none left.

The animals which make this (coral) skeleton protect themselves by using stinging tentacles and hiding in their little pukas. One tiny, soft animal called a coral polyp lives in each tiny puka. At night they bloom out something like a flower, but during the day they usually stay down inside their pukas. Corals are important to all marine life and to us. They are the reef builders. When they have built a good sized colony, the fishes and crabs and hundreds of other small animals find places to hide and live in the coral crevices. If the corals weren't there, we would not have our beautiful fishes near our shores.

This animal (Linkia)--how does it protect itself? Does it have a hard shell? Does it have stinging spines? Does it have sharp teeth? Does anyone know how this sea star protects itself? (some may say it sticks to rocks) True, it clings to things. It also just lets its enemy eat an arm or two because in a few weeks it grows a new one. Some sea stars grow an arm at the rate of about 1/2 inch every ten days. How many arms does it have? (5) Most sea stars only have five arms, but some have more (hold up Acanthaster). This sea star has sixteen to eighteen arms. It also has spines for protection. It is called a crown-of-thorns, and these are the thorns. You can find sea stars in

different shapes and colors. (hold up cushion star). This is a cushion sea star. How many arms does it have? (5)

A relative of the sea star is the sea urchin. (large test) When alive, it has spines all over it. You will find urchins with short spines along the reef often in holes they make themselves by waving their arms and grinding away the rock. These urchins can poke you, but if you are careful you can handle them. The urchins with very long spines are called wana in Hawaii. Their spines contain poison so don't touch them.

(cone shell) This cone shell has a special means of protection. It has a hard shell, but it can also shoot a poisonous dart from the small end of the shell. It mainly uses this dart to kill its food, but it can use it on you if you aren't careful. If you find one don't pick it up but if you do always hold it on the fat end. The animal can pull way back into the shell, so you may think the cone shell is empty and the animal gone. The cone may fool you and sneak out far enough to sting if you are not careful.

(swimming crab in mold) This crab uses a couple of ways to protect itself. Can you tell how? (It has pincers, a hard shell, and it runs or swims away very fast into a hiding place.)

Now, you have seen how some animals protect themselves. (If you have time, you can review some of them with the class.) Do you know who is their worst enemy? People. People are the ones who pollute water with their factories and sewage. People often destroy the homes of the animals by digging up the bottom of the ocean. When you walk on the reef, if you turn a rock over to find what's under it, please remember to put it back, right side up. Many times small crabs, shrimps and other things

live there. They stay protected under the rock and if you expose the bottom, they may be eaten by larger animals. Also the eggs of fish and many animals are laid under rocks. If you disturb them, the eggs may never hatch. So, don't be a reef wrecker when you go to the beach.

BASKET LECTURE ADDITIONS

Ecology of Coral Reef, Crown-of-Thorns and Triton

(coral skeleton) This is a coral skeleton. All we see here are the "bones" of the tiny animals who used to live in these pukas. When alive, coral animals living in the pukas give this coral a greenish or brownish color. Some corals are red, or blue, or yellow. This animal (Acanthaster) likes to feed on the tiny coral animals. It's a sea star, called a crown-of-thorns. Can you guess why it's called that? It protects itself with these thorns, and it can sting your hand if it is alive. In Australia a few years ago, suddenly there seemed to be thousands of these sea stars all over, eating away the Great Barrier Reef. Scientists were afraid they would kill the whole reef. We don't know the reasons for this sudden population explosion. Some feel that the balance of the coral reefs was changed by man's pollution. Also outer parts of the reef were blasted and dredged for harbors. All this perhaps allowed more young crown-of-thorns to grow up. Another reason could be that people were over collecting the triton's trumpet and the giant balloon fish (hold them up). These two animals and the triggerfish (hold it up) are able to eat the crown-of-thorns and keep its population down. However, if people over-collect these animals, the sea stars multiply and destroy areas of reef.

BUTTERFLYFISH: Ornate butterflyfish (Chaetodon ornatissimus) also called kikakapu by ancient Hawaiians. Kika=energetic; kapu=forbidden. The butter-flyfish family is the most numerous on the reefs. This fish is not a real fish but it is cast

from a mold made by a real fish. The ornate butterflyfish feed on coral polyps.

Butterflyfishes have several ways to protect themselves:

1) When a predator attacks, they raise the spiny dorsal fin to make it difficult to be swallowed.

2) They never stray far from their reef.

3) The butterflyfish family contains a variety of species; all colored differently but all very flat. The color patterns may serve to warn predators that they have very little flesh to eat.

Pointing out fish anatomy:

Dorsal fin (along back) used for stabilization.

Ventral fin used for braking.

Anal fin used for stabalization.

Pectoral fin used for propulsion and sculling.

Caudal fin used for propulation.

Lateral line has sensory cells enabling fish to feel changes in water movement.

Gill slit passes water through mouth, over gill filaments and out gill slit. The gills remove the dissolved oxygen from the water.

BRIGHT EYED DAMSELFISH: This fish is a member of the damselfish family (Abudefduf imparipennis). Damselfishes were not important to ancient Hawaiians and few have Hawaiian names. The fish grows to 6 inches long and is not important as a food fish. These fishes protect themselves by hovering close to cover, and diving to safety when threatened.

SEA HORSE: This fish is related to the pipefish. The pipefish is a straightened form of sea horse. For protection the sea horse uses camouflage by wrap-

ping its tail around algae and swaying with the current thus blending with the algae. The sea horse has independently movable eyes. It can look up with one eye and down with the other. Sea horses and pipefishes suck in their food with long snouts. They eat tiny organisms and fish that swim within reach.

CORAL (Pocillopora damicornis): This coral is commonly found in fairly calm, shallow water. The coral grows in rounded finely branched clumps. This piece has galls or pouches in which tiny crabs live (Hapalocarcinus marsupialis). We call them gall crabs. The female settles in the coral and stays there for her life time. The coral actually grows around her, forming a pouch and imprisoning her forever. She eats microscopic animals suspended in the water that flows through her chamber. The male crab is extremely small. He goes from one gall to another crawling through the small holes to fertilize the females' eggs.

SHARK SKIN: Shark skin consists of denticles, or modified teeth shaped somewhat like the shark tooth and microscopic in size. The skin is abrasive and can be used as sandpaper.

PENTACERASTER SEA STAR: This sea star has a thick body, and is not as common as the Linkia sea star. It is found in deeper water, has sharp spinelets on the dorsal side.

MAN 'O WAR or PHYSALIA: Physalia is not a true jellyfish. A jellyfish is one polyp-like animal while the Physalia is a colony of cooperating hydroid animals. The colony is not a free swimming organism like the pulsating jellyfish. It has an air sac which floats along the surface allowing wind patterns to dictate direction. The long tentacles hanging below the float contain stinging nematocysts. The colony paralizes a fish, then posses it to the digesting group. The sting is painful and sometimes fatal.

TAPE/SLIDE SHOWS

AQUARIUM ANIMALS -- PROTECTION

The animals you are about to see can be found in this aquarium and museum. All marine animals have different ways of taking care of themselves in the ocean. We call this self protection. Listen carefully about each animal and how it protects itself.

The sea anemone is an animal which does not move very quickly. As you will notice it has many tentacles and on each tentacle are stinging cells. The sea anemone uses the stinging cells to protect itself and to paralize prey which it eats.

Coral is composed of many tiny animals which are like the sea anemone. They live in large groups and make a hard limy skeleton like the coral head in this slide. They also have stinging cells in their tentacles.

The cowrie snail's shell protects it from many enemies. This picture shows the shell and the soft parts of the cowrie. You'll notice its eyes, (pause) feelers, (pause) and its foot with which it crawls around on rocks. Notice also its mantle which covers the shell. This cowrie's red mantle helps hide the cowrie because it is the same color as the red sponges it lives on and eats.

You may see this hermit crab on the reef. It lives together with the sea anemone which it keeps on its shell. The stinging tentacles of the sea anemone give the hermit crab protection and the hermit crab moves the sea anemone around to new feeding areas. The sea anemone can't move very fast on its own. As the hermit crab grows, it has to find a bigger shell to live in. When it finds a bigger shell it touches the anemone in a certain way telling the animal that it's time to move. The sea anemone

releases its strong grip and the hermit crab moves it onto the new shell.

Fishes have very interesting ways of defending themselves. The following slides will show different kinds of fishes and their means of self defense.

The moray eel or puhi has long shrp teeth used to grab fish and to defend itself. Eels are different from other fishes because they are long and do not have many fins. They don't need fins to slither around in holes or pukas. Pukas hide the eels from enemies.

The squirrelfishes, called ala'ihi and menpachi, sleep during the day under ledges and in caves and come out at night. Their red color is not visable at night and squirrelfishes have sharp spines and scales which protect them.

The angelfishes and butterflyfishes are brightly colored. They have no weapons for defense, so they stay close to hiding places. If in danger these fish dart quickly out of sight.

This is the bandit angelfish named for its mask. Angelfishes look very similar to butterflyfishes.

The raccoon butterflyfish is named for the black mask across its eyes.

Here is the long-nosed butterflyfish. The Hawaiian name for this animal is lau wiliwili nukunuku oi'oi. The Hawaiian name refers to the shape of the animal; lau wili which is a type of leaf and nukunuku refers to the long nose.

Here is a fish that doesn't need to hide. The surgeonfish is named for the spine at the base of its tail. The modified scale or spine is long and very sharp and can make a bad cut in any animal which tries to eat it. The surgeonfish can also make a bad cut in you if you try to take it off a spear without being careful.

This is the goatfish, the kumu or weke. It feeds on the many little ani-

mals that live in the sand and uses the long barbels coming off its chin to taste things that are good to eat. The goatfish protects itself by swimming quickly away if another fish tries to eat it.

This is the triggerfish known in Hawaii as humuhumu nukunuku a'puaa which means grunting fish with a nose like a pig. This fish protects itself by wedging itself inside a hole and sticking up its spines to hold itself in tightly.

This is the anglerfish. It looks like a big rock and hides among rocks from predators. It's called an anglerfish because it has a spine on its head above its eye. The spine looks like a worm and the anglerfish wiggles it, attracting small fish to eat.

The giant pufferfish protects itself by swallowing lots of water and blowing up like a balloon so it is too big to eat.

This brightly colored fish doesn't need to hide from predators. The cleaner wrasse is like a barber to other fish. Fish need to have dead scales and parasites clipped off their bodies. The cleaner wrasse does this job. Other fish don't chase or eat cleaner wrasses because they need to be cleaned.

This is called a parrotfish because its teeth are fused together and look somewhat like the beak of a parrot. At night while they sleep, some parrotfishes make a cocoon around themselves. This cocoon keeps other fish from smelling the parrotfish so they can sleep safely.

The Hawaiian monk seal is found only in Hawaii and its main enemy is the shark. If you'll notice, under its flipper is a scar from a shark bite. Monk seals must depend on their ability to swim fast and to leap onto shore to avoid sharks.

This is the white tip shark. You can see it in the aquarium. A shark

has many rows of sharp teeth and when it looses one, another tooth moves into the place of the lost one. Sharks depend on their teeth for feeding so you can see why having many teeth protects the shark.

Recap: As you have seen, ocean animals have different ways of protecting themselves. Some, like cowries, blend with their surrounds. Others use weapons such as stinging tentacles, (pause) sharp teeth, (pause) or sharp scales (pause). Another protective method is the ability to swim quickly or dart to cover.

SANDY, ROCKY, and CORAL COMMUNITIES

If you swim or snorkel in Hawaiian waters you will be able to see several distinct types of underwater areas. This slide lecture describes 3 of these, the rocky, sandy, and coral habitats.

Wherever there is a lava bench or cliff, large rocks called boulders or small stones called rubble, the area is called a rocky marine habitat. Such an area is usually subject to strong waves and currents during several months of the year so that only small widely spaced encrusting corals occur there. The animals that live here are able to withstand strong wave action and many eat seaweed called limu in Hawaiian.

Brittle stars are flat and able to crawl into tiny crevices within or beneath rocks. They scavenge for food particles which collect under the rocks or extend an arm or two to trap debris which floats by.

The snakehead cowrie is able to cling to rocks with its large foot. Small fishes called gobies also cling to rocks with their fused sucker-like ventral fins.

Small and large crabs live in rocky marine habitats. The 7-11 crab finds homes in crevices in the rocks and clings to surfaces with their legs.

The short-spined sea urchin has may tube feet. Each tube foot has a

sucker-like base which holds the animal to the rocks. This urchin grazes on seaweed and has the peculiar habit of placing small rocks and seaweed on the top part of its body.

The achilles tang grazes on limu. It is a strong, fast swimmer and can avoid being smashed against the rocks by the strong waves.

Most Hawaiian sand is white and consists of ground up corals, shells, and the hard parts of other animals. However, some sand can be black and is formed from ground up lava. Areas of very fine sand are known as mud flats.

Sandy areas usually occur in quiet water between coral reef patches or from the fringing reefs to the shore. The animals that live here are all capable of using the sand in one way or another.

The bubble shell lives under the sand during the day and at night glides through or on the sand on its huge foot searching for bits of food which is trapped in the sandy ridges.

The black sea cucumber remains inactive during the day but at night it sweeps up debris from the sand with its vacuum cleaner-like mouth.

Some tubeworms live in the sand and build a tube around themselves with saliva and sand grains. The worms extend their feather-like tentacles into the water and catch tiny particles--their food. When disturbed, they snap in their tentacles and crawl to the bottom of their tubes.

The box crab usually lies buried in the sand and only its eyes may be seen. It emerges to catch animals like the tubeworms which it crushes with its specialized claws. The box crab also uses these claws to protect its soft parts from sand and enemies. Its sand color also helps it to remain concealed from its enemies.

The indian wrasse is so named for the projection above its head. This wrasse swims above the sand catching small animals. When danger threatens it dives sideways into the sand for protection. It can even swim under the sand so that if one digs for it at its point of entry it will not be found.

The goatfish lives on sand animals. It probes for these with the feeler-like barbles under its chin. If it finds a juicy morsel it digs it out. Several fishes follow the goatfish as it probes the sand and sometimes get a free meal if a sand animal is too quick for the goatfish.

Most Hawaiian coral reefs are called fringing reefs because they are located along the shoreline. Reefs are composed mainly of corals, and plants called coralline algae. Underneath lies a limestone or lava base. Corals are colonies of animals called polyps. Polyps form the limestone cups in which they live and as new polyps grow, the coral colony increases in size. Coralline algae grows in the cracks of dead corals to cement them together into a firm mass called a reef platform.

Coral reefs vary in size from very large to a single coral head. Living Hawaiian coral reefs are mainly composed of finger coral, lobe coral, and head coral. The yellow and pink colors of these corals are caused by a small algae which lives in the coral polyps and helps them grow. Dead, bleached coral is usually white. A reef is not only a colony composed of coral but includes all the animals and plants living there. Reefs develop best in clear, shallow, quiet water and the animals that live here do not need to be strong swimmers or grip the substrate, rather, many are very flattened so that they can slip between the coral crevices if danger threatens.

This colorful slate pencil urchin is one of our common coral reef animals. It has fewer tube feet than the urchins that live in rock areas.

The cleaning shrimp (pause) and the cleaner wrasse live in particular spots on the reef called cleaning stations. A fish will come to these stations to be tickled by these animals which in turn pick out the fish's parasites.

The octopus lives in holes on the reef, and often may be seen crawling about in search of small crabs and sea snails to eat.

Another common coral reef fish is the saddleback wrasse which will snap up any small moving animal.

Ornate butterflyfishes eat coral polyps and defend large areas of coral against other coral eating fishes.

Parrotfishes move along the reef eating algae which grows on dead coral. They leave toothmarks on the coral and help to return the coral to sand.

We have shown only a few animals that live in the three major marine habitats in Hawaii. In rocky areas the animals typically feed on algae and must be strong swimmers or rock grippers. In sandy areas the animals are adapted to use the sand as a hiding place or can probe for food there. On coral reefs the animals feed on a variety of things including corals and are often flattened so that they can squeeze into cracks.

CAMOUFLAGE

Camouflage is the art of deception. In this slide series we will see how animals fool their enemies by blending into the surroundings and predatory animals fool or deceive their prey by remaining unnoticed until the final, fatal moment. (pause) There are several kinds of camouflage. We will show you four types.

Sharks are countershaded--that is if another animal views a shark from above, it blends with the darker waters below and if it is viewed from below it blends in with the brighter waters above. This means that the shark or any other countershaded

animal is darker on top than it is on the bottom.

Ulua (pause) and tuna live in open water. To deceive their enemies their bodies are also countershaded; dark on top; light underneath.

Another way that an animal can be camouflaged is to blend in with other animals of its own kind. We call this schooling. A predator, like a shark, locates and zeros in on a single fish. A single fish is not as easy to see in a school of fish as alone in the water. This confuses the predator and it cannot decide which fish to chase.

The most common form of camouflage is blending in with the surroundings. The sea hare looks like a clump of algae. Cowrie shells have colored mantles which cover their shells and when the mantles are up, they blend in with coral, algae or sponges.

Algae grows on cone shells, which helps them blend in with their surroundings. This oak cone shell looks like the rocks around it.

The leaffish looks like a leaf of seaweed. It sways in the current to fool its predators and also its prey. The leaffish looks so much like seaweed that smaller fish swim too near and are suddenly swallowed.

Many animals like the blenny live in rocky or sandy areas. Their skin is colored to blend in with the sand and rubble.

This dragonette is sand colored and buries in the sand. The eyes protrude above the sand watching for prey to swim by.

The best known example of camouflage is the flatfish. This fish changes its color, so when it moves to a new location it blends in perfectly with that particular area. When the flatfish is disturbed it swims away and on can see it easily.

The flying gurnard is also colored like the sand to blend in with it.

The box crab looks like a rock when its large claws are pulled in toward

its head. Like other sand dwellers it is an off-white color.

The anglerfish also looks like a rock in its natural habitat so that predators cannot see it and so it can stalk its prey more easily.

Groupers blend with the substrate. They usually wait near the bases of coral heads and in rubble for small fish.

This pygmy angelfish lives in and among ruddish brown stones and algal covered rocks. Its color helps it remain inconspicuous while it darts about.

The master of camouflage is the octopus which can change the color of its skin to match practically anything in its surroundings. It can even change the color of different parts of its skin. If the head and two arms are on a green rock, they match the rock. If the rest of the arms are on reddish rocks, their color blends with the reddish color. The octopus can even change the texture of its skin to match. The skin can be bumpy or smooth.

When one animal resembles another animal for protective camouflage this is referred to as mimicry. The sea slug mimics the coral polyp to hide from predators as it feeds on the coral. The body of the nudibranch or sea slug on this coral is shaped and colored to resemble the polyps of the coral. As the nudibranch feeds on the coral it stores the coral pigment and becomes the same color as the coral.

Tube corals come in various colors, gold, black, or red. As the nudibranch feeds on these different colored corals it takes on the coloration of that coral.

Camouflage is a device whereby an animal uses color or shape to blend with the background. Camouflaged animals deceive their predators and prey. Here are several means of camouflage various animals use.

1) Countershading--some animals that live in open water are

dark on top and light below. The tuna uses countershading.

2) Camouflaging--some animals that live on the bottom look like the rocks and algae around them. The octopus uses such a blending technique.

3) Mimicry--some animals copy other animals in looks or behavior. The nudibranch uses mimicry because it looks like the coral polyps.

Can you find this animal? What kind of deception is it using?

DANGEROUS MARINE ANIMALS

This lecture will deal with those animals reef walkers, swimmers, and divers may encounter in their activities.

While snorkeling your eye will be attracted by colorful patches among the rocks. These are often sponges. These simple animals have minute sharp spicules of glass or lime in their tissues. These spicules can cause skin irritation much like steel wool does.

These are urchins called ina in Hawaiian. You will be amazed to see many of these urchins embedded in holes in reef rocks. These small urchins dig themselves into and wear away the limestone rocks by constantly moving their spines. As you walk over the reef, step carefully, for though the spines are not poisonous, they can puncture your foot.

This slide shows you a closeup view of the skeletal structure of a coral colony. Notice the sharp edges. Coral can cause scrapes and cuts. Coral wounds often heal slowly because the wounds have jagged edges and may contain small pieces of coral. You must treat coral cuts with special care because they infect easily. Wash them care-

fully then apply first aid cream. See a doctor if they don't seem to be healing. When you are exploring the reef areas, wear suitable clothing like gloves, shoes, and even jeans.

Hawaiians call long spined sea urchins wana. They have long, thin, and extremely sharp spines. When you touch an urchin the brittle spines break off in your skin leaving dark purple stinging spots. Some spines contain a substance that causes severe pain. This slide is an example of the adult wana coloration.

Here is a juvenile wana. The spines are banded black and white. It will also deliver a powerful sting. Wana spines are usually not dangerous and doctors do not often remove them. Gently massage the area to break up the spines in the skin and soak the area in hot water. The spines will dissolve in a few days.

If you touch this crown-of-thorns sea star you will be stung. The spines of this animal contain a toxin or poison that is much like that of the wana but they do not break off in your skin.

The octopus is quite shy and rather docile. Octopus in Hawaii are small as compared to the large species found in the Pacific Northwest. The only threat to a diver's safety is the strong, parrot-like beak at the mouth that could inflict a wound if the octopus is carelessly handled.

Most moray eels have sharp fang-like teeth curved toward their throat. If a moray bites you, your natural reaction is to jerk back. This jerk will only make the cut larger. If the eel bites, try to relax, until the eel realizes you are too big to eat and lets go. Thoroughly clean the bite. There is danger of infection due to bacteria on the eel's teeth so see a doctor. Most eels are timid animals and will bite only if you intrude in their hiding places. Don't put your hands in pukas.

Not a great deal is known about the deadly sea snake. Fortunately, only a few sea snakes have ever been seen in Hawaii. Most species frequent the waters of the Indo-Pacific regions. You may mistake an eel for a sea snake. An eel doesn't have a paddle-like tail.

The jellyfish is related to the coral. These animals have stinging tentacles fringing their oral cavity. The strands of stinging cells trail below their bodies. These strands can grow to lengths of 20 feet or more.

Jellyfish (pause) and the Portugese man-of-war stings can be very painful. The initial sensation is one of sharp pain similar to being stung by a wasp. The area will swell and itch and possible muscle cramps will occur. The swelling and itching may continue for a few days. Common treatments which break down the stinging cells of jellyfish and Portugese man-of-war are alcohol, lemon juice, ammonia or powdered meat tenderizer if you are not allergic to it.

Several types of sharks are found in our waters. Three of these are the hammerhead (pause) the grey reef shark (pause) and the white tip shark (pause). All sharks should be considered dangerous. If you want to get up close to a shark, do it from the dry side of an aquarium tank. If you should encounter one while snorkeling or swimming, do not panic. Do nothing eratic like splashing or screaming. Sharks may mistake your actions and sounds as those of a wounded animal. Rather than frightening a shark, splashing and screaming may attract it. Swimming slowly and evenly to the shore is your best bet. Again, do nothing unusual.

This is a stingray. Stingrays are ordinarily gentle animals but if stepped on or mishandled, they can inflict severe gashes by flicking their tails. At the base of the tail is a sharp barb capable of making a deep cut. Some stingrays also have poison

in their barbs. It is a good idea to watch stingrays from a distance. If stabbed, soak the area in hot water for 15 to 90 minutes and see a doctor.

Many marine animals have sharp spines to protect themselves. This spiny lobster should only be handled with gloves.

Fishes, too, have spiny projections around their heads, in their fins, and some like the squirrelfishes even have sharp cutting scales.

The surgeonfish is so named because of the modified scale or knife near the tail. In many members of this group of fish, the knife is different in color from the rest of the body.

This surgeonfish or kala as it is known in Hawaiian when frightened, uses a quick flicking movement of its tail to turn its knives into dangerous, razor sharp weapons that can seriously hurt a diver or fisherman.

These fish are called nohu in Hawaiian. They are scorpionfish and are some of the most beautiful and also most dangerous fish in local waters. The lionfish, another nohu, has large fins and beautiful markings. It is also dangerous. All the fins and spines contain a poison that can cause severe pain to anyone careless. The next scorpionfish, the turkeyfish, is much like the lionfish except that its fins are somewhat shorter and it lacks some of the color. If you are stung by these fish, get out of the water immediately. Apply a constricting band around the area and soak it in as hot water as you can stand. Call a doctor as soon as possible.

The marine community is a world of its own--one which is pleasant for people to observe, but remember, you are an intruder in the marine world. These animals are protecting themselves and we must respect their right to protection.

TIDEPOOL

Have you walked along a rocky coast and noticed a tidal pool? What do you see when you casually glance over those areas of water trapped by rocks and land? If you look at the tidepools themselves you will find that they are of two types, those created by periodic wave splashes (splash pools) and those formed by retreating tides (intertidal pools).

Splash pools are situated high on rocky benches and the animals living within them must tolerate wide variations in temperature and salinity.

Intertidal pools disappear at high tide and are reformed at low tide. Animals living within this type of pool are able to withstand strong wave surge. If you peer more closely into a tidal pool, you will view an exciting realm of marine life that you would have missed with a casual glance. The next 6 slides are of different tidepool animals that all belong to a large group called mollusks. Mollusk means soft body.

CHITON: The chitons are very primative animals. They have been on the earth since before the age of dinosaurs. Note the eight protective plates along the back; these cover the soft muscular foot.

SEA HARE: Does this animal look like a rabbit to you? It is called a sea hare, spelled h, a, r, e. It is a mollusk called a hare, because it has projections on its head that look somewhat like rabbit ears. When the hare is disturbed, it gives off deep purple ink, like an octopus. This is not surprising since both the sea hare and octopus are mollusks. Sea hares live in the tidal zone and feed on algae.

LIMPET: The Hawaiian name for limpet is opihi. Some species are edible, and served as part of ancient Hawaiians' diets. The opihi in this slide taste bitter. Limpets are nocturnal, grazing on algae at night. During the day, the opihi clings to the

wave-swept rocks with its powerful foot. The tightly fitting cap shaped shell prevents the soft inner body from drying out during low tide.

NERITE: The nerite is another rock clinging mollusk. It feeds at night on the algae. The Hawaiian name for the nerite is pipipi, and it is also used for food.

COWRIE: One of the prettier mollusks, the cowrie, is usually inactive, resting in holes, during the day. The frilly projections around the mantle are the cowrie's gills. The mantle slides up completely over the shell, keeping it shiny.

NUDIBRANCH: Nudibranchs, or sea slugs, are among the most colorful invertebrates. Invertebrates are animals without backbones. Nudibranch means "naked gill", and refers to the feathery gills projecting from the creature's back. Nudibranchs eat corals, sponges, and algae.

TUBEWORMS: If you approach a tidal area carefully, you'll probably see some feather-like tentacles waving in the water. The tentacles are filtering water for food particles. If you poke them they will snap back into their tubes. This animal, called a feather duster is actually a segmented worm that creates a tubular house. It crawls up the tube to feed, and retreats when frightened.

SPAGHETTI WORM: You'll have an unusual sensation if you touch these white spaghetti-like strings. They are sticky and are the feeding tentacles of a spaghetti worm. They trap food which is then reeled into the worm's mouth. The worm itself is segmented and looks like an earthworm. It lives deeply imbedded in a tube under the rocks and sand.

ROCK CRAB: Most of the dark colored crabs you see sunning themselves on the rocks near the water are rock crabs. Their bodies are fairly flat allowing them to slide into small cracks and crevices. Rock crabs are unusual because they will drown

if they are completely immersed in water for a long time. They must, however, live near the water to wet their gill chambers.

HERMIT CRABS: Hermit crabs are crustaceans, like crabs, lobsters, and shrimp. The hermit crab, however, has no hard skeleton covering its abdomen, and must live in empty mollusk shells for protection. This crab has modified legs that enable it to hold onto the inside of the shell. As the crab grows bigger, it must find a larger shell to move into. Hermit crabs are scavengers, eating whatever they find on the ocean floor.

BANDANA PRAWN: Another colorful crustacean is the bandana prawn which often lives in crevices of tidal pools.

BARNACLES: Some rocks are covered with small animals called barnacles. Barnacles remain tightly closed during the low tide to keep themselves from drying up. When they are covered with water, they open and feathery legs sweep the water to bring food into their mouths. These animals have jointed legs and are related to crabs, lobsters and shrimp.

LINKIA: This sea star is common in Hawaii. We call it linckia. You'll find linkia in several colors. Sea stars have the unique ability to regenerate a missing arm. This is a means of protection. A predator can feed on an arm or two, and later the sea star regenerates new arms at the rate of about one inch per week. Different stars eat different foods--some eat coral polyps, some dead material found on the ocean bottom; others eat two-shelled mollusks like clams.

SEA URCHIN: Here is a common reef urchin called ina. You'll see it in various colors. These particular urchins hollow out a cavity in the rock by constantly moving their spines. The cavity serves as a protective home. The urchin slowly moves

around its home, scraping the algae off the cavity sides.

WANA: Another type of urchin is locallled called the wana. The long, extremely sharp spines contain a poison that causes a severe sting to humans. The spines are brittle, and easily break off in your skin. This animal is alert to intruders, setting its spines in motion as a warning.

SEA CUCUMBER: The sea cucumber is long and thick, shaped like a cucumber--hence the name. Some sea cucumbers are camouflaged by a layer of sand sticking to their leathery skin. The sea cucumber has tentacles around the mouth which sweep the ocean floor, scooping sand and mud into its digestive tract where food is taken from the sand, and the sand expelled. The sea cucumber is related to sea stars and sea urchins.

SERPENT STARS: This type of sea star is called the brittle star because there is a definite break-point between the central disk and the arms. When a predator catches a brittle star, it can detach its arm, leaving it to wiggle and distract the predator while the star scurries to the nearest cover.

SERGEANT MAJOR: There are several species of fishes you will frequently find in intertidal areas. One of these is the sergeant major or maomao. You'll recognize the sergeant major because it has stripes across its back like a soldier's arm patch. A relative of the sergeant major, the kupipi, also lives in tidal pools. It has a black and yellow spot near its dorsal fin. Young sergeant majors and kupipi live in protected rocky tidepools. As they grow older, they move to deeper water.

GOBY: Gobies are adaptable fish. They can tolerate extreme changes in temperature and salinity. Their pelvic fins are fused together, forming a cup which helps the fish cling to rocks in high surf.

BLENNY: Here is another adaptable fish. The blenny or rock skipper can memorize the tidepools in its area. At low tide, when the pools are land-locked, the blenny jumps over the rocks from one to another to escape its enemies.

If you are in a tidepool area, be careful to turn the rocks back over after looking at them so that the animals are replaced or come back to their original homes.

HAWAIIANA

The old Hawaiians placed a great deal of importance on the sea, and like most primitive societies, they attributed the various movements of sea life to super-natural causes. Numerous deities were set up to account for occurrences and activities the natives did not understand or wished to explain. Rituals were a fact of life for these people, their very survival dependent on being in good favor with the gods. God images were carved out of wood or rock and kept in shrines, or ko'a, where offerings could be made and ceremonies held. Smaller statues or images were even used as weights for fishing lines--the natives believing that keeping that image close to the actual fish would assure a good catch. This slide shows an example of a stone god image.

The Hawaiians also believed in aumakua, or "personal gods", which were supposed to watch over them and bring them luck. Aumakua were spirits that chose to take the shape of a particular plant or animal. That plant or animal became kapu (off-limits) to the worshipper, and it received offerings and respect in return for its help. For instance, sharks, called mano in Hawaiian, were often acknowledged as aumakua. If a shark was your aumakua, any shark you encountered would be subject to respectful treatment just in case it happened to be the aumakua. Fish that were abnormally colored or shaped were treated as aumakua--after all, what other reason could there be for a

fish to be so unlike others of the species? If a fisherman found such a fish in his net, he would instantly assume that the aumakua had blundered in its travels and would toss it back into the water exclaiming, "Tsa! What are you doing in my net?"

This slide shows a school of weke, or goatfish. These fish were well liked by the Hawaiians and are considered good food fish by modern fishermen. Weke were also used frequently as offerings to gods. There are two basic colorations for these fish, red and white--the red were used for certain occasions and the white for others. The Hawaiians neatly established a balance between sea and land animals for use in offerings. Since the ocean played such a large part in their lives certain animals were set up as counterparts to land animals to be used if the normal land sacrifice was in short supply. The weke was one such fish. These were called "sea pigs", or pua'a kai, replacements for pigs which were highly valued as a food source.

Other fish that were used as pua'a kai were the triggerfish, or humuhumu nukunuku apua'a--the name means "fish with the nose of a pig". Some people swear this fish is a cure for tuberculosis--others feel otherwise. However, it is interesting to note that some Hawaiians considered this fish good for firewood and nothing else. The ahole-hole was used in sacrifices when a white fleshed fish was required, and when pigs were not available. This fish was also considered a delicacy (pause) and when royalty craved it--it had to be brought to them alive. Sometimes this required traveling many miles so the resourceful Hawaiians kept the fish alive by wrapping it in wet seaweed, or limu.

The ancient Hawaiians were great believers in omens. Sea and weather conditions were indicators of upcoming events, (pause) and even the movements of schools of fish. For example, a large school of big-eye, or aweoweo, moving inshore was thought to foretell the death of a high chief. The fish itself was well prized as food but its appear-

ance was regarded with sorrow.

One monarch who was particularly fond of fish was Kamehameha III, whose favorite fish was supposedly a squirrelfish, or ala'ihi. These fish are mainly nocturnal and spend daylight hours in caves and holes, called pukas in Hawaiian. Ala'ihi are difficult to prepare as they have sharp, very rigid spines and rough scales, but if the king says they taste good who are we to argue?

The monarchy and the witchdoctors called kahuna, had much to do with fishing practices. Kikakapu were fish considered off-limits, or kapu to everybody. This butterflyfish is a kikakapu. Many times either the king or the kahuna would invoke a rule limiting or prohibiting the capture of certain fish. There were seasonal laws on fishing used by the Hawaiians that have been shown to coincide with the spawning schedules of fish. The Hawaiians were infinitely wiser than today's fishermen where conservation was concerned.

If you have an opportunity to do any snorkeling, a fish you will undoubtedly see is the wrasse, or hinalea. The hinalea is not used much as a food fish today, as its flesh is very soft and has a strong odor, but in the days of early Hawaii, it was used in, of all things, a pregnancy ritual. Two hinaleas were wrapped in ti leaves and cooked over coals. The first belonged to Ku (a powerful god) and before it was eaten a prayer was invoked to Ku asking that he grant this woman a child. If a male child was wanted, masculine duties were mentioned--if a female, then female work was included. The second fish belonged to Hina, an important goddess, and the same prayer was used.

Hawaiians, like all fishermen, knew that fish would not always be in the fisherman's favorite spot waiting to be caught. To insure that food would be available ponds were built, and the fish that was most often kept in these ponds was the mullet or

'ama'ama. The 'ama'ama was a "sea pig" or pua'a kai and having good supplies of this fish helped greatly in ceremonies. Ponds provided the Hawaiians with one method of insuring their catch, but they had many other methods of catching fish. For example, this cowrie was caught and its shell used in the fashioning of this hook and lure device. This strange looking lure was used to catch the octopus. The lure was dragged along the bottom and the octopus, thinking a good meal was passing in review, would lunge at the shell. Once the octopus had a firm hold on the shell, the lure would be jerked violently and the poor mollusk would be impaled on the shark bone hook.

The Hawaiians had many techniquies to make their fishing easier. On days when a breeze made seeing into the water difficult, the Hawaiian would chew up kukui nuts, which are oily, and spit the mash into the water. The oil would form a film and smooth the surface of the water. If there had been more Hawaiians to chew kukui nuts, Captain Cook's journals may have recorded the first oil slicks in Hawaii.

Deep sea fishing was also practiced by Hawaiians but to a less degree than the inshore reef fishing. This was due to the nature of the tools available and open water conditions. When it was done, however, lines were set with many hooks trailing off a main line. This insured the maximum catch for a single line. One fish that was caught with this technique is the jack, or ulua. Ironically, all those pictures one sees of the old Hawaiian fisherman with the net slung over his shoulder are inaccurate. Nets were not used efficiently in Hawaii until the Japanese brought their knowledge of net fishing to the islands. Even so, one would have to admit that the Hawaiians did alright.

ANIMAL COMMUNICATION

Animals send messages to each other in many ways. If you were an animal underwater with a message to send, how might you communicate? How would you tell others that you had sharp, deadly spines? were not good to eat? wanted a mate? or had some service to render? This slide show gives some of the different ways marine animals communicate with each other.

Many fishes see colors. Some animals take advantage of this fact and advertise their message by using bright colors.

The flatworm's message is that is it inedible. It is brightly colored so that animals on the reef soon learn not to eat it. The spanish dancer is also brightly colored and is avoided as food by reef fishes.

Surgeonfishes transmit the message that they are dangerous because they have modified bony scales on their caudal peduncles with which they can deliver a painful cut to an attacker. Often these blades or spots around them are brightly colored to draw attention to this weapon. Predators only have to attack these animals once before they learn to avoid them.

The lionfish has poisonous spines in its fins and is brightly colored to advertise the fact. It does not need to be an active swimmer because of its powerful defensive devices.

The male fiddler crab communicates to other fiddler crabs by displaying his large claw which is colored differently from the rest of his body. He does this to warn away other males and to attract females. Sometimes animals are totally another color to advertise their sex. This rare Pacific basslet male is blue, the female is yellow. Parrotfish and wrasse males also differ from females and each sex is recognized

by the other. This is a female hilu wrasse and this is the male.

Shape plays an important roll in communication. This is a male flame wrasse. He has a high dorsal fin whereas the female's dorsal fin is small. The decoy scorpionfish's dorsal fin is shaped like a small fish. When the scorpionfish sits very still and raises its fin, the fin looks like a small fish above a rock. When an animal approaches to eat the fin, the "rock" swallows the animal.

Touch is important in communication. This hermit crab carries anemones on its shell. Sea anemones hold tightly to the shell surface with their pedal disk. As the hermit crab grows it has to find a larger shell in which to live. When it finds a suitable shell, the crab tickles the sea anemone around the base of disk, telling the anemone to release its grip. It is then placed on the new shell by the crab.

Some animals use a combination of coloration, movement, and touch to send messages. The cleaner wrasse is brightly colored (pause) and moves in such a way as to advertise that it has a service to render. (pause) Fishes with parasites are called hosts. They look for cleaner wrasses to have the parasites removed. The cleaner wrasse moves over the fish and tickles the host with its pelvic fins while it pulls out the parasites. The fish seems to enjoy the tickling and when it wants to be tickled again it tries to attract the cleaner's attention by assuming unusual postures. It may stand on its head or on its tail or pose motionless in the water with all fins raised.

Electric fishes have an unusual way of communicating through their specially developed organs for sending and receiving electrical pulses. Change in pulse rate may mean "I am courting, I am hunting, or I am resting". Because they live in very muddy water and can't see well they use electricity in much the same way as we use language for communication.

Animals can also send out chemical signals to be smelled by others of their own species. A female swimming crab for example, sends out a chemical that tells the male she is ready to molt and mate. A male is attracted and holds on to her, protecting her during the molt, mating with her just after.

Animals such as squirrelfishes called menpachi communicate vocally with each other by grinding specialized teeth located in their throats. If they are courting the sounds produced are different fromthosegiven when the animals are resting or feeding.

The grinding or scraping noises made by surgeonfishes and parrotfishes while feeding on the reef attracts other herbivores to the limu source. This form of communication is not deliberately caused by the feeding fishes. However, the sounds they produce serve as signals that food is available.

Marine mammals especially use sound to convey a number of behaviors. Seals (pause), dolphins (pause) and whales (pause) use grunts, bellows, and squeaks for courting, locating each other, and finding food. Each species uses different sounds so that if two species can hear each other, they only pay attention to the sounds of their own kind.

Maine animals can communicate with each other in a number of ways. They may use color, shape, movement, touch, electricity, chemicals or sound to advertise a message or service.

PATCH REEF FISHES

Patch reefs are those isolated islands of coral and rubble surrounded by sand and whose bases are most commonly located in depths between ten and eightly feet below the surface. The different animals of patch reefs vary with depth. The shallow

water species being replaced by their deeper water counterparts as depth increases. The average Hawaiian patch reef is structured mainly of dead coral rubble at the base and live coral heads on the sides and top. These corals are usually of the genera Porites, (pause) Pocillopora, (pause) or Montipora (pause). Some reefs are only a thin layer of encrusting coral over lava. The giant table-top Acropora and staghorn corals characteristic of tropical Indo-Pacific reefs do not occur in Hawaii. The average Hawaiian patch reef is about 15 feet in diameter but may also be as small as a single large coral head or so large that one is not able to see one end from the other. The point at which one stops calling an area a patch reef and refers to it as a barrier or fringing reef primarily depends on how it is situated in relation to the shore and neighboring reefs.

Not all of our Hawaiian fishes are to be found at one time on any one patch reef. Many species do not even occur on reefs but are found in open water, tidepools or other areas. Small patch reefs may have only a few resident species and include occasional wanderers. All of the patch reef species participate in a variety of activities, feeding, resting, territorial defense, and courtship behavior.

Feeding dominates the daily activity of reef fishes. Algae eating herbivores such as the surgeonfishes browse along the bottom. Parrotfishes, also herbivores, feed on algae which they obtain by biting off chunks of dead coral with their beaks. Parrotfishes and surgeonfishes are not residents of a single patch reef but travel from patch to patch to feed. Predators such as the trumpetfish associate with schools of surgeonfishes and parrotfishes taking advantage of the flushing effect of the school's grazing and prey on small animals scared out from under cover, sucking them up with their long snouts.

Some resident damselfishes (pause) and butterflyfishes are carnivores and

feed on small invertebrates in the water column but seek shelter in the patch reef if alarmed. Butterflyfishes like the longnose butterflyfish nip at minute animals on the substrate, and the oval butterflyfish nips at coral polyps. Hawkfishes may be seen sitting on coral heads waiting for larger prey to come close enough to be snapped up and eels may be observed waiting for prey in the holes on the reef. Goatfishes (pause) and wrasses are also carnivores and feed on small crustacea and fishes on the bottom. Many times the behaviors of fishes and even their body shapes are not obvious. In fact, some divers are amazed when they see a rock swallow a fish. What they actually have seen is the fine art of camouflage displayed by fishes such as the leaf fish which resembles the bottom be it rock, or algae and wait with endless patience until a bite-sized fish swims within eating range. Then activity is sudden as these rock fishes lunge foreward and inhale their prey.

Some damselfishes are called tyrants of the reef because the more common ones defend territories containing algal mats which they eat and lay their eggs on. If an unlucky fish enters one of these territories, the resident damselfish will bite and chase it away.

During the late spring and early summer months, daily activity is complicated with spawning. Fishes in tropical regions may spawn all year round while in temperate regions the breeding seasons are usually well defined. Hawaii seems to be somewhat in the middle with fishes spawning all year round with increased frequency during May, June, and July. Maomao damselfish prepare an area such as the flat side of a rock on which the eggs are to be laid. The female lays the eggs and the male follows her, fertilizing them. The eggs are stuck to the substrate. Both adults are extremely defensive and will guard the nest area vigorously until the eggs hatch. Sometimes the

eggs are attacked by too many fishes for the dameselfishes to chase away and the eggs are eaten.

As evening approaches, reef fishes begin to descend to the substrate. Wrasses start to disappear beneath the sand where they sleep about 30 minutes before sunset. Other fishes hide in holes. At night not only are the day fishes asleep, but they possess a slightly different color pattern. This is the coloration of the threadfin butterflyfish during the day. This is its pattern at night. As the day fishes go into holes for the night, night fishes start emerging from these same resting places. At this time predators like jacks (pause) and sharks are particularly active and all fishes remain fairly close to the substrate. After twilight, night fishes concern themselves mostly with feeding over the reef or in midwater. Among the nocturnal fishes common on Hawaiian patch reefs there are: lionfishes, squirrelfishes, and cardinalfishes. As the sun rises in the morning, the night fishes change places once again with the day fishes. The morning activities are first centered around the re-establishment of territories and feeding ranges. The routine of feeding is occasionally broken by attacks of predators, competition for territories, and during the breeding season, by spawning.

The more one looks into the community of a patch reef, the more complicated the picture becomes. The reef is not merely a massive assemblage of fishes feeding, fighting and breeding, but it is a complex network of interactions with defined relationships. With patience, the careful observer can sit watching these interactions and begin for himself to unravel one of the mysteries that marine biologists study.

TAPE/SLIDE SHOWS (additional material)

SANDY, ROCKY, and CORAL COMMUNITIES

The following has been inserted as the last paragraph from the end.

At night most of the day or diurnal animals find shelter and night or nocturnal animals come out to feed. Because there are so few available hiding places, the day animals take over those places that were occupied by the night animals. Nocturnal animals represent a whole new community. All have special adaptations for finding food at night. This squirrelfish, a nocturnal animal, has very large eyes.

DANGEROUS MARINE ANIMALS

To be done before or after the Dangerous Marine Animals tape-lecture. You'll need to open the case containing the shells, (key with the blue tag is in the projection booth).

Cone shells--there are approximately six hundred species of cones. If you are a shell collector, you'll be looking for this conically shaped shell.

The animal itself is a carnivore which means it eats other animals. It has teeth modified to act as poisoned darts. These darts will give a powerful sting and some species are toxic enough to kill a person. All cones have the ability to sting. We have not had a death attributed to a cone sting here in Hawaii, but we don't want you to be the first.

When you find a cone, always assume it is alive; the animal may be retracted so far back that you think the cone is not inhabited. Hold the cone by the thick end (show with example from shell case). Always carry it away from your body, and keep it in a goodie bag, not a pocket in your swimsuit!

TIDAL POOLS

A re-arranged tape has been made stressing pollution at the end. Other than the added concepts that man and nature can cause imbalances to the ecology of tidal pools, the whole story is in your copy of the tape/slide show TIDAL POOLS.

SOME ENDEMIC HAWAIIAN FISHES (30 species)

SQUIRRELFISHES

Adioryx xantherythrus, called "'ala'ihi" is one of the most numerous of the squirrelfishes. It is said to have been the favorite fish of King Kamehameha III, although it is too bony to be recognized as a popular food fish. It is red with longitudinal white bars. Adioryx ensifer is red with horizontal yellow bands thus distinguishing it from A. xantherythrus. It is also a good but bony food fish.

BUTTERFLYFISHES

Chaetodon fremblii (kikakapu) is distinguished by striking horizontal blue bars running the length of its yellow body. Chaetodon miliaris (lauhau) is the commonest of our inshore species and is characterized by black bars at the caudal base and over its eyes. It also has black spots forming vertical bars.

ANGELFISHES

Centropyge potteri (orange with wavy blue lines) and C. fisheri (orange) are found in fairly shallow to deep water. Holocanthus arcuatus (grey and white) is the largest of our angelfishes. Angelfishes are not mentioned in Hawaiian lore.

WRASSES

Thalassoma duperrey (hinalea or saddleback wrasse) is perhaps the most abundant species of reef areas. It is distinguished by a brownish shoulder bar on adult individuals. Juveniles are green with a longitudinal stripe running the length of their bodies. Labroides phthirophagus (cleaner wrasse) is one of the smallest of the wrasses. It was discovered in the 1950s and has no Hawaiian name.

DAMSELFISHES

Dascyllus albisella (aloiloi) is quite plentiful in reef areas. It is black

or greyish in color as an adult and juveniles have a single white spot in the middle of upper portion of body.

INTRODUCED FISHES OF HAWAII

Introducing new species of fishes has value to both commercial fish raisers and sports fishing, but finding an appropriate species to introduce is a matter which requires extensive research. Several things must be considered; first, will the new arrival fit in easily without upsetting the ecological balance and without causing harm to the already established organisms in the area. Second, will the fish survive and reproduce in its new surroundings. Third, can the fish provide (pound for pound) more food then it consumes. Fourth, is the fish, or can the fish become toxic. Many fish are rejected from consideration as possible immigrants to Hawaii because they contain fish poisons or parasites unknown in Hawaii.

Over 27 new kinds of freshwater fishes have been introduced into Hawaii's streams and reservoirs, some unfortunately by amateur aquarists. The channel catfish of southeastern United States and the chinese catfish, or oopu-kui are used here for food but have a tendancy to taste like mud when caught from the reservoirs. The tilapias which were thought to control vegetation, are now competing with other fish for animal food. Other introduced freshwater fishes are basses, blue gills, and trout from North America; tucunare and oscars from South America; and carp and snakeheads from Asia.

Hawaii has been used as a guinea pig for the introduction of several varieties of saltwater fish, the Marquesan sardine became established but there were never enough for tuna bait. A fish that did become established as a result of being carelessly released with the sardines is C. engelii, a species of mullet. It is now competing for food with a larger mullet, Mugil cephalus which is currently being raised for the market.

In 1956, 2,000 small groupers and snappers were transported from Moorea in the Society Islands to Hawaii and released. Among those released were the groupers Ephinephelus merra, E. hexagonatus and Cephalopholis argus; and the snapper Lutjanus vaigiensis.

Two years later 8 species of groupers and snappers were released, this time from the Marquesan Islands into Kaneohe Bay, Oahu. Notable in this shipment was the colorful snapper Lutjanus kasmira, easily identified by its yellow and blue stripes.

In October 1966 the two snappers L. vaigiensis and L. kasmira were declared open to year-round fishing. By 1969 these fishes, especially the blue-lined snapper, had entered the commercial and sport fisheries of Hawaii. As much as 132 pounds of blue-lined snapper have been taken off the Big Island by handlining during a single fishing trip.

It is not known why the other species of groupers and snappers were unable to establish themselves, but undoubtably further research is necessary to safeguard the environment from damaging mistakes.

FISH SCHOOLS and AGGREGATIONS

Schooling among fishes is a common phenomenon. If we compare the myriad of schooling species we find many similarities. In general, what we may call a 'school' is made up of individuals which are oriented parallel to each other. Parallel orientation is coordinated by the fish's eyes and lateral line sensory system. We also find that the schooling individuals are of the same species, nearly the same size, and no particular animal stands out.

A schooling fish is able to respond very quickly to another's movement, producing a unified effect. Fish schools do not have any leaders, rather, the

fish travel en masse behind those individuals which temporarily assume the lead. The leading fish are continually falling back and are overtaken by the fish behind.

Aggregations of fishes are also commonly observed. Aggregating individuals behave more independently than synchronized schools and form temporary groups for feeding or spawning.

We not only find groups of reef fishes consisting wholly of a single species but also often composed of several species. This composite group is called a mixed species aggregation. In Hawaii large aggregations of surgeonfishes consisting mostly of the manini (Acanthurus triostegus) can be seen flowing over the reefs, feeding on filamentous algae. The aggregation often contains other benthic (substrate) feeders such as juvenile parrotfishes. On occasion one aggregation may be attracted to another group by the presence of a common food source. For a short time there is a mixing of age classes and species groups which soon separate after feeding.

We can now view a mass of fish as either a synchronized school moving in timed unison or an aggregation of single or mixed species moving about in peaceful confusion. Whichever the case, fish assemblages have a number of adaptive advantages.

A large school of fishes may provide as much protection to individuals as hiding under rocks. In order to be most successful, a predatory fish, like any good hunter, must be able to pick out a specific target for attack. If it relys on 'hit or miss' tactics its chances of success are negligible.

Schooling prevents the predator from finding particular individuals. In addition, schooling species tend to be camouflaged--either countershaded, barred or stripped. These color patterns often confuse the predator because it is very difficult to distinguish an individual within a school or aggregation.

A schooling or aggregating group also has an increased sensing capacity. Once a predator is detected by an individual, alarm spreads rapidly throughout the group.

Some predators such as tunas and jacks are also known to school. While these species may be preyed upon by larger animals and thus enjoy the protection schooling affords, they also school to attack smaller prey. Attack by schooling predators can scatter and separate the prey's school enabling the predators to select out a specific victim.

Fishermen have long known that schools of tuna and flocks of birds work together while feeding on small anchovies and herrings. The tuna school will drive the small fish toward the water's surface and block them from below. The prey might still escape by leaping over the heads of the tuna and swimming away were it not for the sea birds which sweep down and keep the small fish below the surface.

The presence of one species may signal availability of food to another species. The stimulus may be food common to both species itself. Some fishes like surgeonfish create a good deal of noise while scraping algae from rocks. This noise plus the observed feeding pattern may signal to another algae eating species that there is food available.

The tigerfish is frequently found wherever South American piranha aggregate. Unlike the piranha, when hungry it attacks large healthy fishes. Once a fish is wounded by the tigerfish, the piranha aggregation closes in snapping at anything in sight. Piranhas and tigerfish illustrate how one species (the tigerfish) may initiate a feeding frenzy in another species (the piranha) on healthy and, therefore, unlikely prey for the piranha.

Many reef fishes, especially some damselfishes are territorial, guarding an area against all intruders which may compete for its algal food. In Hawaii a common grey damselfish (Pomacentrus jenkinsi) guards patches of algae as its territory. The damselfish can easily chase away one or two surgeonfish which may attempt to feed on the algae and three or four surgeonfish may prove a greater challenge. When a huge aggregation of surgeonfish overruns the area, the damselfish soon gives up chasing and swims helplessly by as the aggregation moves over the area. Without aggregating, individual surgeonfish would not have succeeded in eating the defended algae.

Fishes that are grouped together in a school or single species aggregation most of the time do not need elaborate courtship rituals or marked sexual differences. These species spawn together, males releasing sperm and females releasing eggs into the water where the eggs are fertilized. The eggs then become part of an immense oceanic aggregation called plankton and develop into larvae.

The energy expended by each fish swimming in a synchronized school is reduced by taking advantage of the vortices or turbulences created by the other fish. This is accomplished in much the same way as race car drivers who save on gasoline by taking advantage of the drag produced by the car ahead of them.

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Buchsbaum, R. and L. J. Milne. 1972. The Lower Animals. Doubleday and Company. A well illustrated book describing the habits and classification of invertebrates. It perhaps is the most useful book on invertebrates for the layman containing lovely color photographs for identification of the major groups.

Burgess, W. and H. Axelrod. 1973. Pacific Marine Fishes. T.F.H. Publications. Books 1, 2, 3, 4 and 5 are presently available. This ambitious series is a collection of color photos (widely variable in quality) with brief but interesting text. Some Hawaiian species are now included; a cumulative index in each book relates to earlier volumes. Expensive, but a good reference.

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Titcomb, Margaret. 1972. Native Use of Fish in Hawaii. University Press of Hawaii. This excellent, entertaining volume is filled with anecdotes about Hawaiian fishes and their use by Hawaiians--a valuable reference and also fun to read.

AQUARIUM FIELD TRIPS

These curriculum materials are divided into concepts and grade levels.

Each level is stapled as a booklet. It is hoped that you can use the suggestions in the pre and post visit sections. We have sent one field trip curriculum envelope to each school. Please leave these materials in your library at all times to prevent their loss.

If sections are missing and you need replacements, or if you have questions, don't hesitate to call the Aquarium Education Department at 923-4725.

Tour Policy -Only public and private elementary, secondary and college groups and special education classes are eligible for tour services.

To eliminate the confusion of many large groups touring the aquarium at the same time, our docents will guide 60 students every 30 minutes. We are assuming that one bus accommodates approximately 60 students. If you must bring more than one bus, plan to send each busload through at 30 minute intervals.

For K-9, tours are available at 10:00, 10:30, 11:00, 11:30, 12:00, and 12:30, Tuesday through Friday.

For 10 through college level, tours are available from 10:00 a.m. until 4:00 p.m. on Tuesday, Thursday and Friday. This level must make appointments one week in advance. Groups of 30 or smaller are preferred.

Appointments - Appointments are made on a first-call first-serve basis, therefore appointments should be phoned well in advance. Call 923-9741 or 923-4725 for your appointments.

GRADES K-3

TOUCH BASKET TALK

Children in grades K-3 tours will receive "Touch Basket" talks with an animal protection theme. No slide lectures are available for this age group.

When you reach the Aquarium, inform the clerk of your arrival. A Docent (tour guide) will greet you, guiding your group to a location suitable for the Touch Basket talk. The Docent will first talk to the group, then allow children to touch certain preserved specimens. This portion of the tour will take approximately 20 minutes. The Docent will next guide your class through the Aquarium which will take approximately 30 minutes.

TEACHER BACKGROUND INFORMATION:

The ocean is an intrinsic part of island living. Understanding and conserving the marine world is important. The Aquarium visit is an opportunity to begin to channel your students' natural curiousity toward constructive attitudes about the ocean and its inhabitants.

Our tours attempt to acquaint the youngsters with certain marine animals, and to foster an attitude of respect for each animal's place in the world.

PRE- and POST-VISIT ACTIVITIES:

Activity 1

Objective: To introduce the field trip and start the children thinking about this experience.

Discussion: What animals will they see? What do they know about sea animals? What is their favorite sea animal? Make a class list of things to find. What is the biggest fish there? What fish has the most teeth? What is the smallest fish?

The biggest shell? (giant clam). Older children could copy individual lists. Younger children might be able to work as groups. Group A finds the biggest fish, Group B the biggest shell.

Upon returning everyone reports what answers they found.

Activity 2

Objective: To focus each child's attention on one marine animal.

Discussion: Before the field trip, perhaps as youngsters are working on the picture sheets, talk with them about their forthcoming experience. Suggest that they select an animal they like at the Aquarium. They should keep their choice a secret. Watch that animal closely; how it moves or a special characteristic like color. When they return from the trip, they will act out their secret animal while the class tries to guess which one it is.

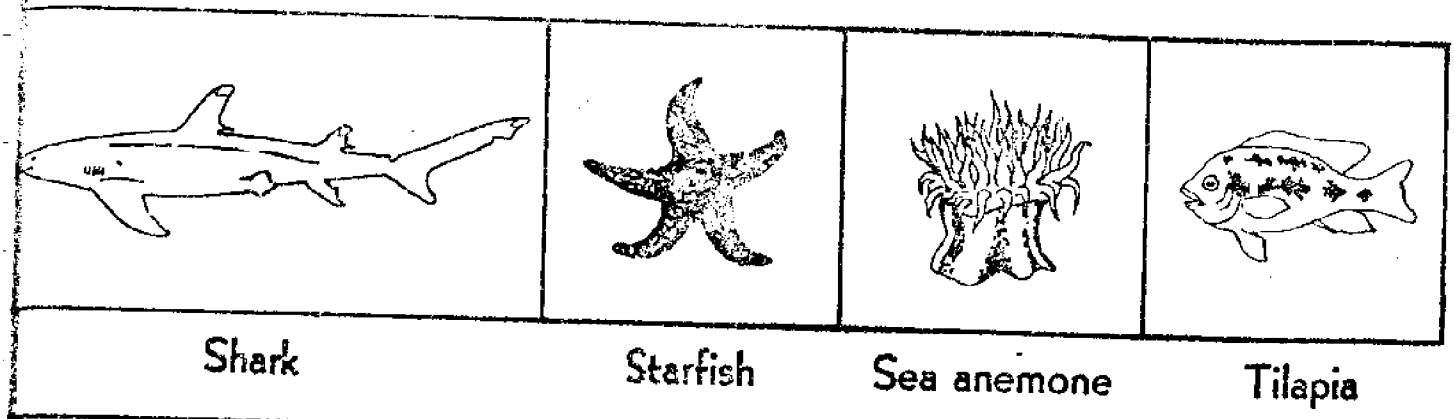
This booklet was prepared by the Education Department, Waikiki Aquarium, with the help of teachers and community members. The following references may help you prepare your students.

Bridges, William. 1970. Book of the Water World. New York Zoological Society.

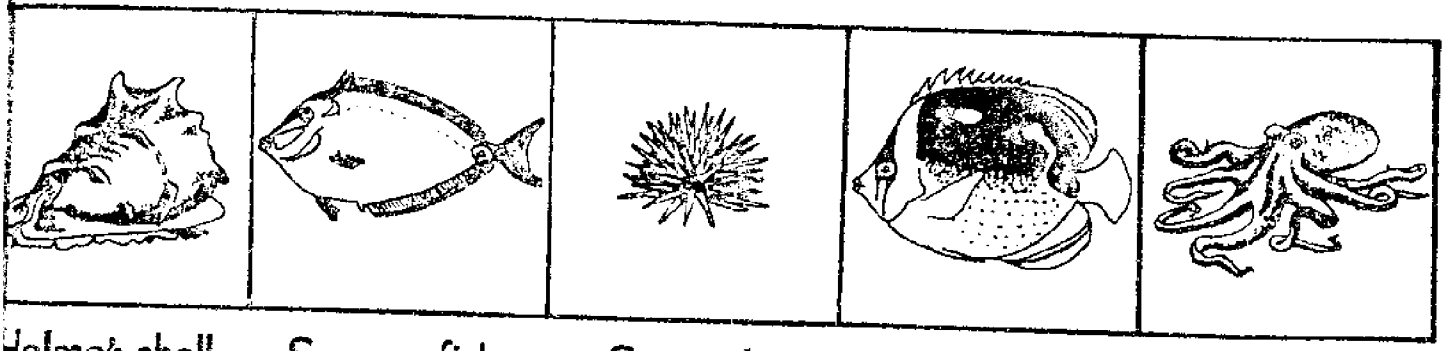
Holling, Holling C. 1957. Pagoo. Houghton-Mifflin. (Delightful first person story of a hermit crab.)

Power, Allan. 1969. The Great Barrier Reef. Paul Hamlyn Pty. Ltd. (Large color pictures of marine animals.)

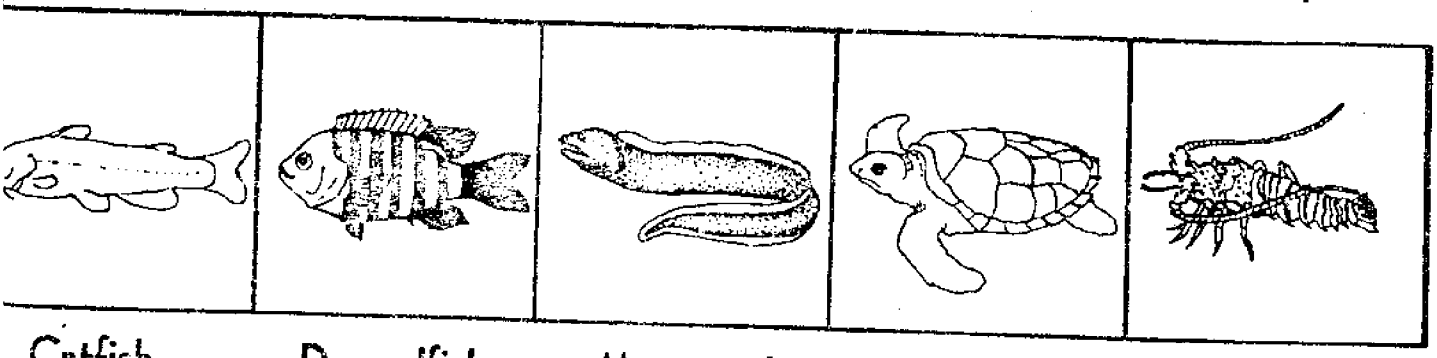
Circle the animals you can find



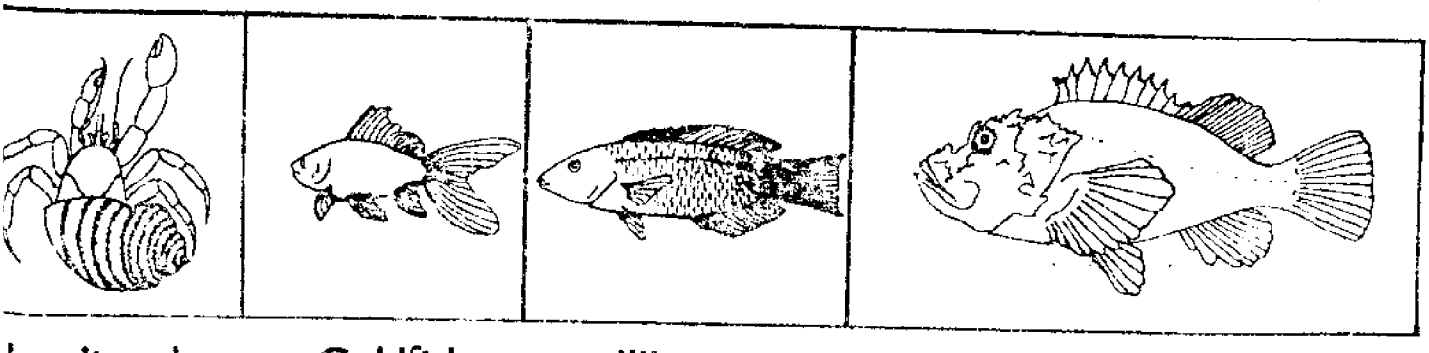
Shark | Starfish | Sea anemone | Tilapia



Helmet shell | Surgeonfish | Sea urchin | Butterflyfish | Octopus



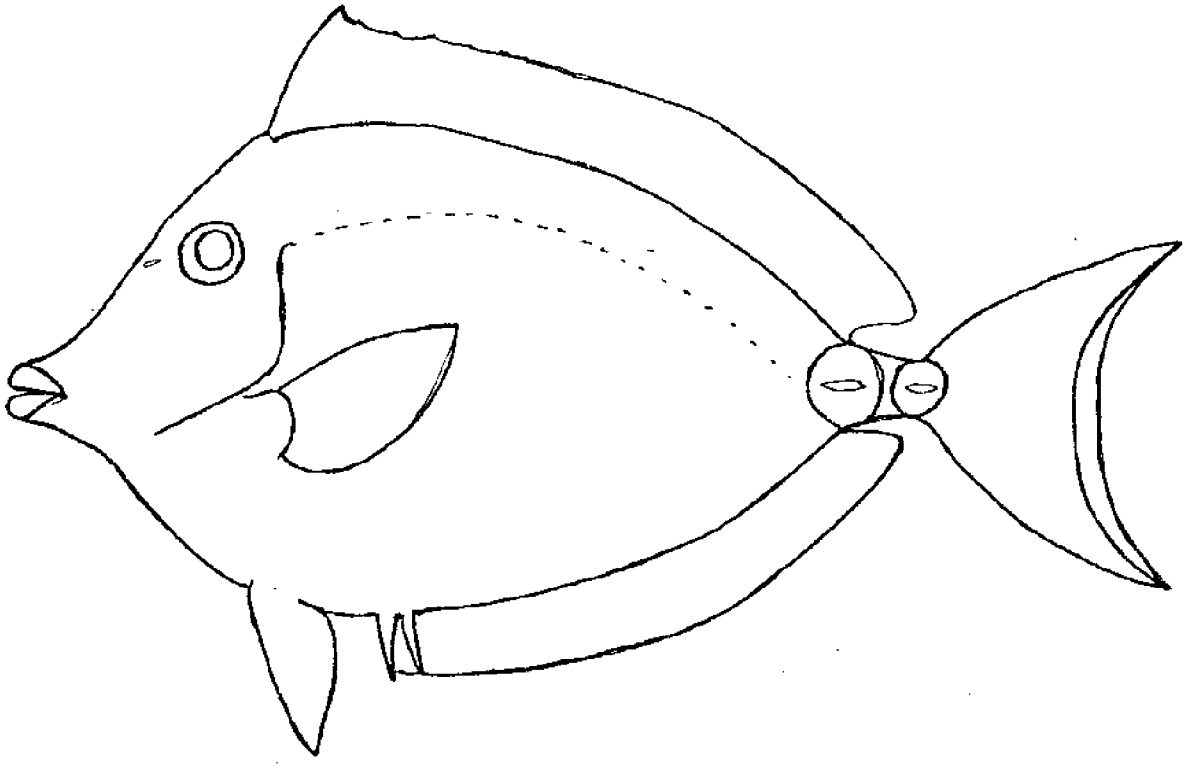
Catfish | Damselfish | Morey eel | Sea turtle | Lobster

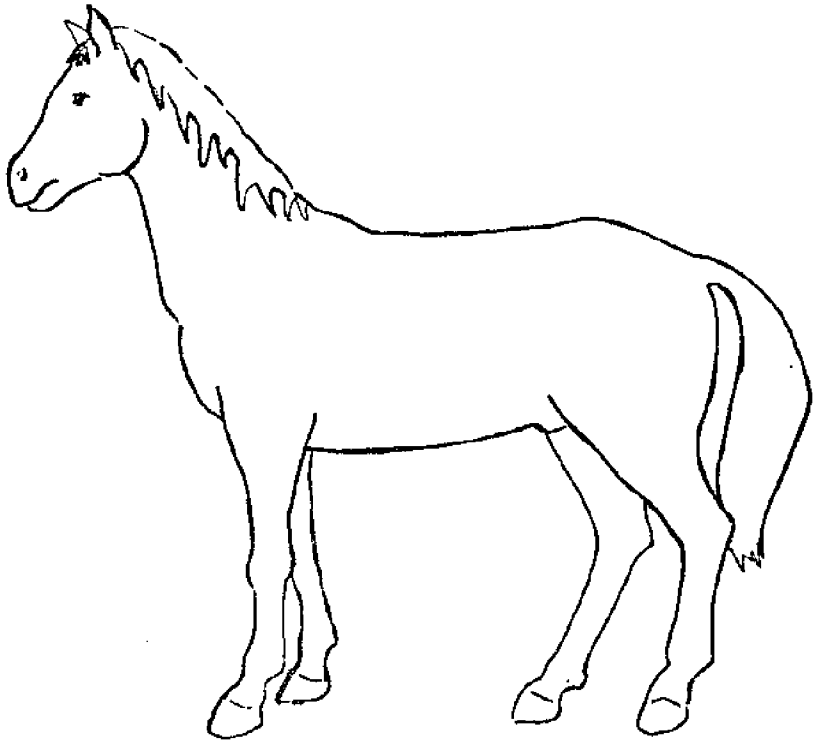


Hermit crab | Goldfish | Wrasse | Scorpionfish

PRE - VISIT

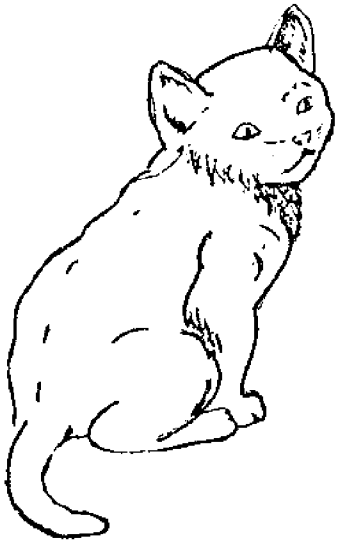
DRAW LINES FROM THE FISH TO THE HORSE, MATCHING THE PARTS OF THEIR BODIES

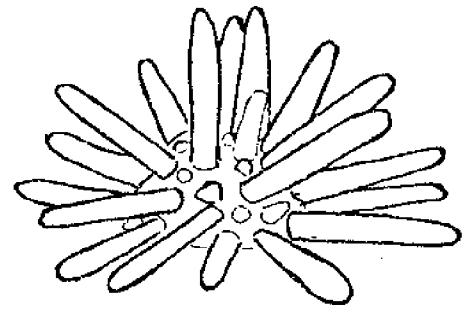


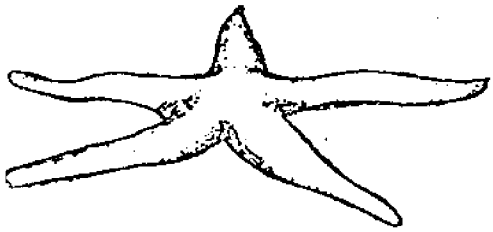


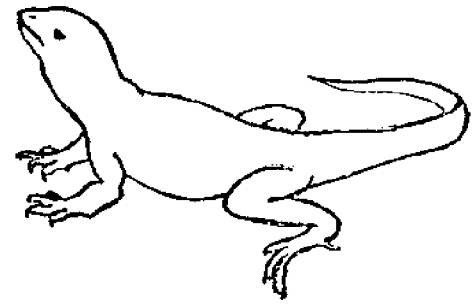
Waikiki Aquarium
University of Hawaii
K-3

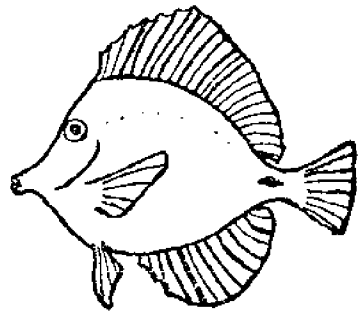
CIRCLE THE ANIMALS THAT LIVE IN THE OCEAN

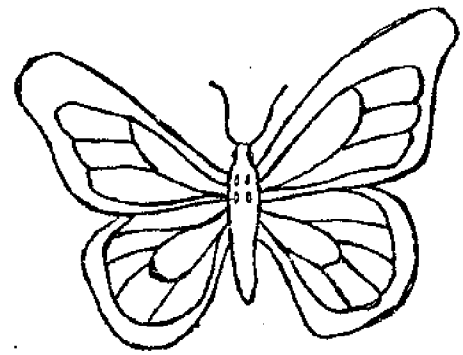


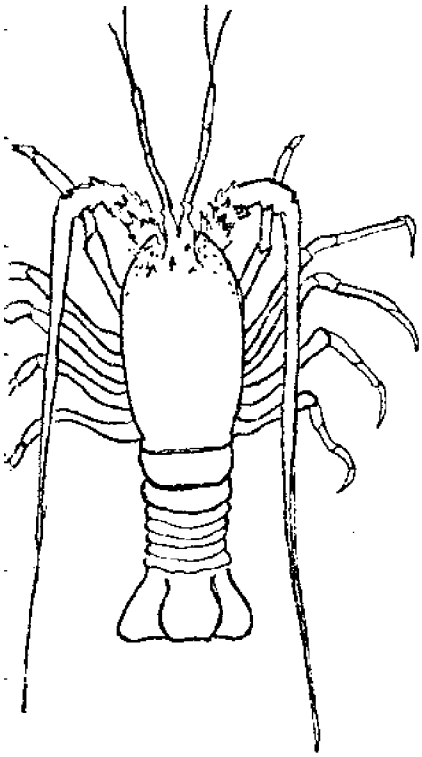








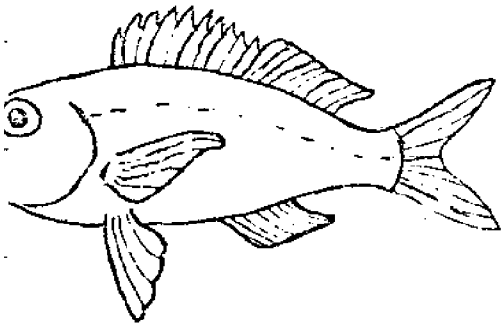


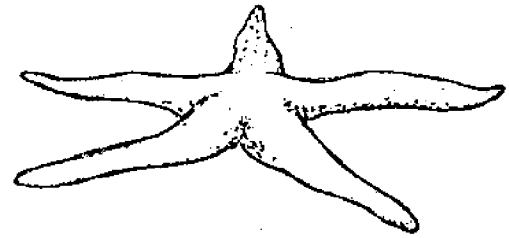


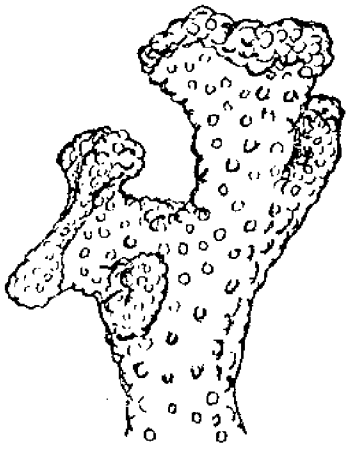
CIRCLE THE OCEAN ANIMAL THAT SWIMS WITH FINS IN THE WATER.

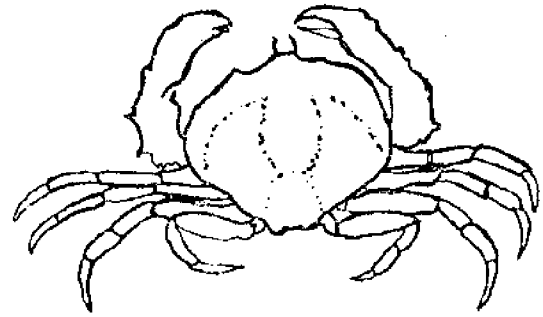
COLOR THE OCEAN ANIMALS THAT WALK ALONG THE BOTTOM.

DRAW A SQUARE AROUND THE ANIMAL THAT SITS STILL ON THE BOTTOM.









Waikiki Aquarium
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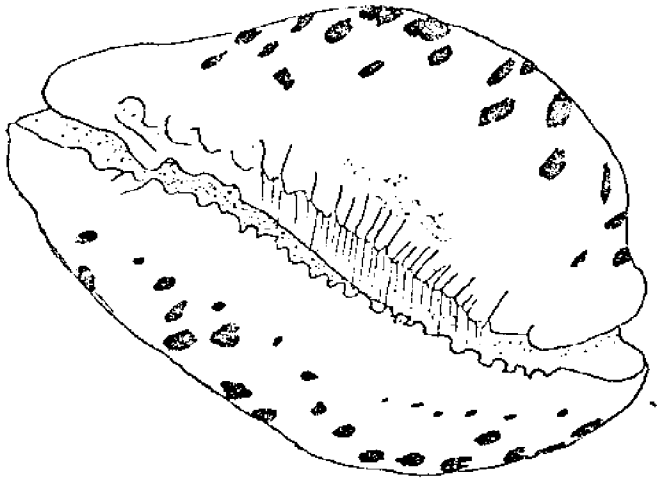
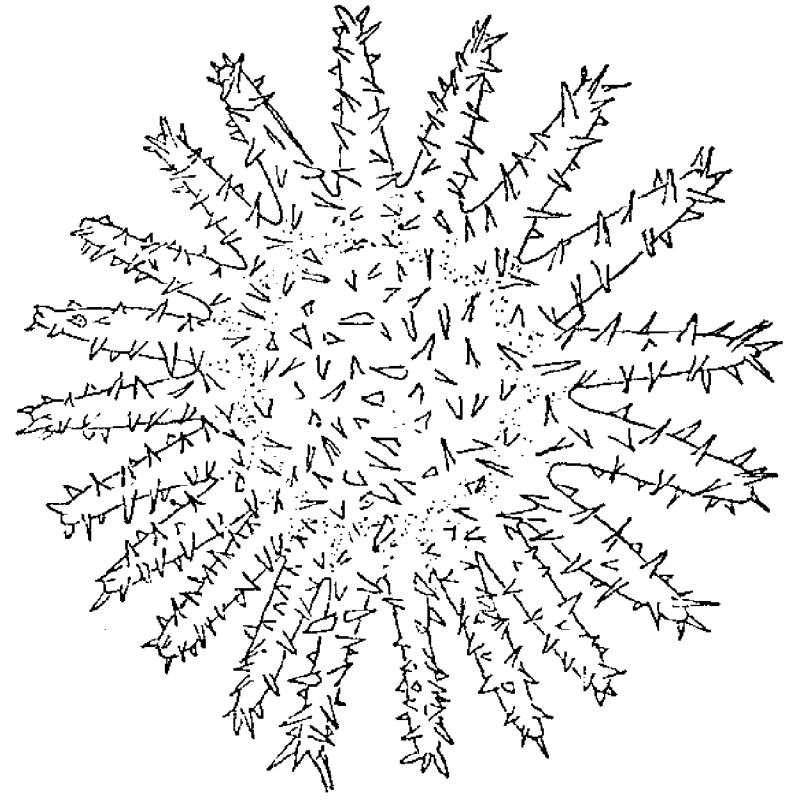
K-3

POST VISIT





COLOR THE ANIMAL THAT

HIDES IN ITS SHELL YELLOW

AS SPINES GREEN OR ORANGE

S SHARP TEETH BROWN OR GREY

GRADES 4 and 5
DANGEROUS MARINE AND ANIMAL PROTECTION TOURS

The Waikiki Aquarium presents the protection concept to grades 4 and 5. Teachers are asked to prepare their classes by aquainting them with marine animal protection and the vocabulary words they will encounter.

Two slide lectures are available for your group. Fourth grade is shown Marine Animal Protection and fifth grade Dangerous Marine Animals. If the majority of your class attended lectures at the Aquarium during previous years and have seen one of these lectures, you may request the one not seen.

When you reach the Aquarium, inform the clerk of your arrival. A Docent (tour guide) will greet you, escorting the class to the lecture room. The slide lecture will take approximately 20 minutes. The Aquarium tour time will vary, averaging approximately 40 minutes.

BACKGROUND INFORMATION FOR TEACHERS:

To insure a meaningful and educational experience for your class, we feel your students should be prepared prior to their visit. The following information will help you understand and teach those concepts presented during your field trip.

Marine animals exhibit various methods of self protection. Some of these protective devices can inflict stings or wounds to humans. We can group these methods as derived from anatomical structure, behavior, or a combination of both.

Anatomical structure includes adaptations of shape, color, and special sense organs. Some of our aquarium animals are excellent examples of unusual protective adaptations.

a. Many fish protect themselves with fin spines or tail spines. The scorpionfish or nohu has poison glands at the base of its spines. If mishandled, the nohu's spines puncture the skin and the poison is shot into the wound. Other fish have spines that are not poisonous but can deter an aggressive enemy.

b. Stingrays have rough and poisonous barbs on the tail. Surgeonfishes have scales modified to sharp blades. These are located at the base of the tail, and as the tail swipes sideways, it inflicts a cut.

c. Jellyfish, sea anemones, and the Portugese man-of-war use stinging cells on their tentacles to catch food. These cells are called nematocysts. Jellyfish or Portugese man-of-war tentacles have thousands of nematocysts and if a person is stung, many welts will appear accompanied by pain and itching. Our local anemones don't have enough toxin in their nematocysts to hurt humans.

d. Other marine animals have rough or spiny skins, and shouldn't be handled except with gloves. The spiny lobster, some fishes and sea urchins are examples of animals with such adaptations. Long spined sea urchins (wana) and the crown-of-thorns starfish have venomous spines and should be avoided.

e. Eels, sharks and some fish have sharp teeth used for catching food and for protection. Sharks have many rows of replacement teeth behind their visible ones. If one falls out, another takes its place. The teeth of fishes like the eel are not poisonous, however, the wounds they cause are often severe and will infect easily.

f. Camouflage is a form of anatomical adaptation. Often animals blend with their surroundings using body shape and color so that their enemies cannot find them. Animals also combine camouflage with specific behaviors to remain undetected. Some, like the blennies and flatfishes remain very still. Others, like the leaffish and sea horse sway with the water imitating seaweed. Sponge and decorator crabs place sponges and seaweed on their bodies.

g. Crabs have hard shells, pincers and sometimes use camouflage for self protection. The 7-11 crab is easy to see because of its bright spots. It is protected by pincers. A crab that uses camouflage as well as pincers is the box crab. The crab settles into the sand and its cream colored shell camouflages it. Examples of these crabs are on display in the museum.

Marine animals also employ behavioral characteristics for protection.

a. Schooling is a behavior that many fish use. By staying together, they can confuse their enemies since predators try to focus on one animal and try to catch it. Schooling makes capture more difficult.

b. Hiding is a behavior used by many unarmed sea animals. Brightly colored butterflyfish must stay close to cover and their flat bodies allow them to slide into small coral or rock crevices. Wrasses dive into the sand if alarmed.

VOCABULARY:
For Classes Viewing the Animal Protection Slide Lecture.

predator--An animal that feeds on other animals.
prey--An animal that is potential food for the predator.
stinging tentacles--Found on sea anemones, jellyfish and the Portugese man-of-war; long appendages lined with stinging cells used to paralize or stun prey.
paralize--To make immobile.

cowrie--A glossy, usually patterned, sea shell or mollusk.
mantle--The portion of the soft-bodied mollusk that makes the hard shell and contains gills for breathing.
fins--Thin membranes on fish that help it swim.
barbels--Feeler-like sensory organs on the "chin" of the goatfish; used to find food under the sand.

VOCABULARY:
For Classes Viewing Dangerous Marine Animals Slide Lecture.*

poison--A substance causing illness or death when eaten or absorbed in the body.
constricting band--Otherwise known as a tourniquet, a bandage twisted tightly to compress blood vessels thereby slowing blood circulation.
nematocysts--stinging cells usually located along the tentacles of jellyfish, sea anemones, hydroids and Portugese man-of-war.
carnivores--Animals which feed on other animals.
herbivores--Animals which feed on plants.

*You might include these words with the vocabulary words for the Animal Protection lecture.

ACTIVITIES:
The activities suggested are based on information supplied by the slide lecture.

PRE-VISIT ACTIVITIES: For classes to view the animal protection concept.

Activity 1

Objective: To introduce the animal protection concept.

Materials: Pictures, illustrations or drawings of common marine animals; e.g. sea urchins, sea stars, fishes.

Discussion: How do you think these animals protect themselves from their enemies? How do you protect yourself?

Extension: Have your students bring to class pictures from newspapers, magazines, etc. exemplifying self protection.

Activity 2

Objective: To emphasize how fish use schooling as a means of protection.

Game: Catch Your Prey.

Players: Two predators; remainder of class is potential prey grouped in a school.

How: a. The prey stay together in a group, moving around play area as a school of fish might.

b. The predators chase prey to catch whoever they can. Caught prey must drop out of the school. The prey must regroup after each predator pass.

c. When all are caught and while the class is still thinking about the game, have a discussion about schooling.

--How does predator manage to catch prey?
--Are slower prey caught first?
--Does the scattering of prey make it difficult for the predator?
--If everyone looked exactly alike, how would the predator find it more difficult to catch prey?

POST-VISIT ACTIVITIES: For classes that viewed the Animal Protection Slide Lecture.

Activity 1

Objective: To identify marine animals on the basis of their protective devices.

Materials: This can be done as an oral or written review and more than one answer may satisfy the question.

If you were a marine animal and had...	what are you?
locking spines or trigger on your back	(triggerfish)
two pincers	(crabs, Hawaiian lobster)
a wiggly worm spine on your head	(anglerfish)
five arms	(sea star, brittle star)
sharp teeth	(shark, eel)
eight arms and a beak	(octopus)
sharp blades near your tail	(surgeonfish)
stinging tentacles	(jellyfish, man-of-war, sea anemones, coral polyps)
poison spines in your fins	(scorpionfish or nohu)
your home on your back	(a mollusk [sea snail], hermit crab, turtle)

Activity 2

Objective: To give class an art experience to describe what they saw.

Materials: Clay, styrofoam, paper mache, toothpicks.

Procedure: Encourage your youngsters to make animals with their protective devices, e.g. fish with spines, eels with teeth.

PRE-VISIT ACTIVITIES: For classes to view the Dangerous Marine Animals Slide Lecture.

Objective: To introduce the concept that some marine organisms protect themselves with teeth and toxins dangerous to man; that people must protect themselves and devise treatments for their wounds.

Discussion: Ask the class if they can think of marine animals that are dangerous to humans. What do you do if you are hurt by these animals? Make a class list of questions students might have concerning dangerous animals and treatments. Bring a copy of this list with you, give it to the Docents who give your group the tour. The Docents will not directly answer those questions that are answered somewhere in the lecture or tour, but will suggest where the answers might be found.

POST-VISIT ACTIVITIES: For classes that viewed the Dangerous Marine Animals Slide Lecture.

This question sheet should be given to the class after the Aquarium visit and slide lecture.

1. Should you handle strange plants and animals? (No.)

2. What should you wear while exploring the reef? (Protective shoes, jeans, even gloves.)

3. If you are stung by something but you didn't see what, should you try to find out? (This question has interesting sides. Doctors need to know what the poison was, yet who would take the time to search if he were alone and in pain?)

4. If stung by jellyfish or the Portugese man-of-war, what should you do? (Use vinegar, alcohol or powdered meat tenderizer to break down proteins of nematocysts.)

5. There are many sea urchins on our reefs--which kind stings? (Wana, long spined.)

6. Are eels poisonous? Explain problems caused by eel bites. (No. The bites infect easily due to bacteria on the eel's teeth. Puncture wounds are difficult to treat.)

7. What precautions should be taken with coral cuts? (They should be washed and kept clean. They infect easily due to bacteria on the coral.)

8. Are sea snakes frequently seen in Hawaii? How could you tell the difference between the sea snake and an eel? (No. Sea snakes have paddle-shaped tails, eels' tails taper to a point.)

9. If you were swimming and spotted a shark, what should you not do? (You shouldn't splash or kick wildly.)

10. All the marine animals must have self protective methods to survive their ocean world. We should treat them with respect. Do you believe these statements to be true or false? Why? (Formulate your own answers.)

AQUARIUM TOUR QUESTIONS:
For Classes Viewing Either Slide Lecture.

All or some of the following questions can be reproduced by the teacher. Students should take the questions with them to the Aquarium, seeking answers on the tour. In the past, teachers have found that if they assign one or two questions per person, students aren't so preoccupied with finding answers that they miss interesting points of the tour.

1. Find and look at the animals listed below. Describe how you think they protect themselves.

butterflyfish (flat body)
cone shell (shell and poison dart)
seal (fast swimmer)
octopus (camouflaging ability, beak and suckers)
moray eel (teeth)
coral (stinging tentacles)
spiny puffer (spines and body expansion)
scorpionfish (poison fin spines)
triton's trumpet shell (shell)

2. Find a sea anemone. Draw a picture of the anemone, and label its stinging tentacles.

3. Watch fish in schools. Why do you think they travel in schools? (protection in numbers)

4. What are the projections on the small portion of the surgeonfishes' tails and what are they for? (blades, cutting)

5. If a shark looses a tooth, what happens? (replacement by rows behind)

6. Describe two different types of sea urchin spines. (1. dark blue-black long-spined poisonous urchin; 2. varied-colored short-spined urchin; 3. blue-black flat-platted splash zone urchin)

7. How is a hermit crab different from other crabs? What does it use for protection? (no shell over abdomen; uses empty mollusk shells for protective home)

This booklet was prepared by the Education Department, Waikiki Aquarium, with the help of teachers and community members. The following references may help you prepare the students.

Edmonson, C. H. 1974. Hawaii's Seashore Treasures. Petroglyph Press Ltd., Hilo, Hawaii.

Goodson, Gar. 1973. The Many Splendored Fishes of Hawaii. Marquest Colorguide Books.

Hobson, E. S. and E. H. Chave. 1972. Hawaiian Reef Animals. University of Hawaii Press.

Power, Allan. The Great Barrier Reef. Paul Hamlyn.

Russell, F. E. 1971. Poisonous Marine Animals. T.F.H. Publications.

GRADES 6 and 7
MARINE COMMUNITIES TOURS

The Waikiki Aquarium presents concepts concerning marine communities and ecology for grades 6 and 7. Teachers are asked to prepare their classes by aquainting them with the vocabulary words they will encounter, as well as ideas about what an animal's environment might include.

Two slide lectures are available for your group. The sixth grade is shown a slide lecture entitled Tidepool Communities which discusses two types of Hawaiian tidepools, the inhabitants and their characteristics. The seventh grade sees Sandy, Rocky and Coral Communities which describes three marine communities, the inhabitants and relationships thereof.

When you reach the Aquarium, tell the clerk. A Docent (tour guide) will greet you and guide your class to the lecture room. The slide lecture will take approximately 20 minutes. The Aquarium tour time varies, averaging about 40 minutes.

BACKGROUND INFORMATION:

Marine communities are diverse, supporting a variety of plants and animals. The lectures and materials provided by the Aquarium for grades 6 and 7 deal with five marine communities; tidal splash zone pools, intertidal pools, rocky, sandy and coral communities.

Two kinds of tidepool areas are discussed. Splash pools are situated high on rocky benches being kept wet by splashing waves. The animals living there are hardy and can adapt to desiccation and changes in water temperature and salinity. Changes occur when low tides don't replenish these pools causing evaporation to take place, or when rains dilute the seawater. Adaptability to these changes is achieved in tidepool animals by their ability to absorb or excrete water to be in equalibrium with their surroundings. Mollusks, barnacles and the one urchin species that inhabit splash zones use protective shells or plates which they clamp tightly to rocks to prevent the animals from being swept away by waves or dried by the sun. Gobies and blennies jump to other pools if conditions become too harsh.

In contrast to the periodic wave replenishment in splash pools, intertidal pools receive regular replenishment. These pools are located at the water's edge, with lava rocks forming their perimeters. A more constant water environment allows a wider variety of animals to live there.

Please stress the importance of conservation when your student enter a marine community. Teach them to enjoy the animals and plants that live there, to observe and study them with care and to return them to the exact place where they were found. This is because each specimen has a special place in his community and may die if returned to the wrong spot. E.g. turned over rocks must be put back with their bottom sides down because different types of plants and animals inhabit the bottom and top sides of the rocks. When animals are taken home, most of them die due to improper care.

If your class wishes to set up an aquarium, be sure to select a few hardy animals and plants and return them to their habitat when you are through. We suggest: aholehole, kupipi, moomoo, blennies, gobies, pebble crabs, brittle stars, pipipi (nerites) and pupu (littorines) and a few algal covered rocks. If you don't know the names or descriptions of these animals or how to set up a marine aquarium obtain a copy of Marine and Freshwater Aquarium Systems for Tropical Animals from the University of Hawaii Sea Grant Office for $1.75. This syllabus was written for the home aquarist in Hawaii.

Pollution is another destructive factor in marine communities. Both man and nature pollute the ocean. Sewage and garbage create an imbalance in marine communities. Bulldozing or fires destroy the natural vegetation and when this occurs silt runs into the water killing many of the reef organisms.

Corals are most important to marine life. At all stages of existence, alive or dead, stony corals meet the needs of reef animals. The calcium carbonate (limestone) formations built by hundreds of coral polyps are called coral reefs. Many small lobsters, crabs and fishes make their homes between coral branches. Coral polyps provide meals for several fishes. Even when dead, coral formations continue to provide shelter. Eventually, dead coral skeletons become the base for new corals to grow, expanding the reef.

The Aquarium has a display showing coral growth lines and growth rates. Hawaiian corals grow approximately 1/4 inch per year. You can calculate the age of those coral heads being painted and sold. Would people be able to pay $5 to take home a 25 year old tree?

Food and shelter are topics that must be touched on when people study marine communities. These are shared and competed for by members of the community. Because shelter is usually at a premium, animals must take turns using it. This switching is done by the nocturnal and diurnal animals. At sunrise and sunset some animals are locating shelter while others are establishing feeding territories. Of course, there are animals like eels and lobsters which maintain permanent territories.

VOCABULARY -- TIDEPOOLS:

pollutants--Any unnatural matter that when introduced to a community will disturb the natural biological balance.
surge--The force of waves on the shore.
salinity--The amount of dissolved salts in water.
splash pools--Pools located high on rocky benches, receiving water from wave splashes.
intertidal pools--Pools located at the water's edge, with rock perimeters and tidal replenishment every 12 hours.
scavenger--An animal that eats whatever organic matter it finds.
omnivore--An animal that feeds on plants and animals.
carnivore--An animal that feeds on other animals.
herbivore--An animal that feeds on plants.
predator--An animal that stalks and feeds on other animals.
nocturnal--Most active at night.

diurnal--Most active during daylight hours.
pelvic fins--The paired fins located on the underside of a fish. The goby has pelvic fins specialized to create suction to secure the fish on rocks in turbulent water.

VOCABULARY -- SANDY, ROCKY AND CORAL COMMUNITIES:

ventral fins--The paired fins located on the underside of a fish.
dorsal fins--Those fins along the top of a fish.
scavenger--An animal that eats whatever organic matter it finds.
habitat--Living space for animals.
fringing reef--Reefs fringing the land.
barbels--Sensory extensions located on the chin of goatfishes.
coral polyps--Tiny sac-like animals with tentacles resembling and related to sea anemone.
coralline algae--A marine plant that forms hard calcium carbonate foliage. This type of algae is important in the reef building process as it helps to cement dead coral together.
algae--A water oriented plant or seaweed, found in many forms, from the minute green covering on wet rocks to kelp forests.
substrate--The ocean bottom.
community--A group of plants and animals which live together and form a recognizable unit.
rubble--Rocks and dead corals loosely piled in an area.
diurnal--Most active during daylight hours.
nocturnal--Most active at night.

ACTIVITIES:

The activities suggested are based on information or concepts discussed in the lecture.

PRE-VISIT ACTIVITIES--For classes to view the Tidepool Communities slide lecture.

Activity 1

Objective: To introduce the idea that tidepools must be respected and protected by the people who frequent them.

Discussion: Compare your own back yard to a tidepool. How would you treat it? Do you turn objects over and leave them overturned, uproot plants, pick all the flowers, pour garbage over the lawn? In what ways do people disrupt tidepools? In what ways might nature disrupt tidepools? List on the board all the animals you can think of that inhabit tidal areas.

Activity 2

Objective: To discover that splash zone animals seek areas above the water level.

Materials: Common splash zone sea snails (nerites, littorines). Clear container with sea water.

Procedure: As animals are dropped in to the water, the class can note the time and position of the snails. Check later as to progress of snails. Note observations. What might explain such behavior on the part of these marine snails? Perhaps research could be suggested to answer the question.

Activity 3

Objective: To observe a form of pollution and its effects.

Materials: Brine shrimp (pet stores have them), sea water, clear container, cooking oil.

Procedure: Observe live active brine shrimp in their sea water. Class should make notes of specific behavior considered normal. Pour oil over surface, enough to cover entire surface. As oxygen level decreases in the container, class should observe and note changes in animal behavior.

POST-VISIT ACTIVITIES--For classes that viewed Tidepools slide lecture.

Activity 1

Objective: Review what was learned about tidepools.

Discussion: Class might write a story about a given animal in a tidal area; incorporate a crisis such as pollution, distructive reef wreakers, a high or low tide or heavy rains. Indicate what might happen to the plants or animals and how they must adjust or die.

Activity 2

Objective: To compare three different splash zone animals and decide what common factor helps them survive.

Discussion: How do the structures of each of these animals allow them to protect themselves from drying out? Limpet (opihi), nerite (pipipi), barnacles.

Materials: Pictures of the animals listed below or specimens.

Conclusion: Students should see that all three animals have shells that clamp down or close to prevent drying.

PRE-VISIT ACTIVITIES--For classes to view the Sandy, Rocky, and Coral Communities lecture.

Activity 1

Objective: To think about the importance of living spaces; how sharing occurs.

Discussion: Shelter on the reef is limited. Animals must share shelter. If everyone on your block had only one house to live in (your house) what would happen? (Guide class to consider "shifts", similar to nocturnal and diurnal animals.

Activity 2

See Activity 2 in Tidepool slide lecture.

Activity 3

Objective: To reinforce the attitude that coral grows slowly and must be left in its natural surroundings.

Discussion: Hawaiian stony corals grow at a rate of about 1/4 inch per year. Have class calculate how old various sized coral heads are. Draw parallels between corals and trees, their importance and the need to conserve them.

POST-VISIT ACTIVITIES--For classes that viewed Sandy, Rocky and Coral Communities slide lecture.

Activity 1

Objective: To review marine communities and what animals might live in them.

Materials: Prepare a question sheet or do this on the board: In what marine communities would these animals live?

moray eel (rocky, coral)
brittle star (under rocks)
box crab (sandy)
opihi or limpet (tidal, rocky)
goatfish (sandy)
butterflyfish (coral reefs)
helmet shell (sandy)

Activity 2

Objective: To think of the possible results of pollution by heavy sedimentation on a coral community.

Discussion: Write a newspaper reporter's story on the cause and apparent effect of pollution on the coral reef community.

Activity 3

Objective: To try to determine those things an aquarist must consider when setting up a tank.

Discussion: If you were an aquarist, and you had to make a home for a certain type of fish, what types of things might you consider in your tank set up? What physical, chemical, and biological requirements? (Answer: water temperature and salinity, aeration, light, substrate, filteration, suitable habitat spaces, compatable animals, feeding habits and food preferences.

AQUARIUM TOUR QUESTIONS

All or some of the following questions can be reproduced by the teacher. Students will benefit most from the tour by taking the questions with them to the aquarium, seeking answers by themselves. Docents will be available to guide them.

1. What are the factors necessary for good coral growth? (light, temperature, clear water, suitable substrate) How long does it take to grow a coral that is 12" in diameter? (1/4" per year, 4 years=1", 4x12=48 years.)

2. Coral is an important part of ocean life. Look through the aquarium and museum and see if you can list three reasons coral is important. (shelter, food, reef builder.)

3. Why do you think many reef fishes have a leterally flattened body design? (To slip between the coral branches and rocks.)

4. How are these animals adapted to live in their communities?

   flatfish--sand (shape and changeable color)
   eel--pukas (elongate bodies)
   squirrelfish--nocturnal (large eyes, red color)
   hawkfish--rocks or coral (cryptic coloration and posing quietly)
   gobies--tidepools (color and suction cup pelvic fins)
   long nose butterflyfish--coral reef (mouth can reach into small holes for food, flat body)
   thompson's grouper--midwater (swim bladder allowing suspension in midwater)

5. This is an exercise in observation. Choose any tank to observe, except tanks 25 and 26. Watch the inhabitants of your tank. List the tank number and animals. If you can't figure out the name of the animal, describe it. After each animal name, write where you think that animal's living space is. When you are done observing your tank, go to tanks 25 and 26. List five of the inhabitants and their living spaces. Do you see any differences in the way different kinds of animals use their habitats? Elaborate.

6. Name 5 different foods that fishes eat. (live fish, algae, coral polyps, sponges, crustaceans, sea stars and urchins, plankton, detritus (organic matter).

7. Find tanks that represent the following communities, list the tank number by the community.

   _____ deep water community
   _____ tidal community
   _____ cave community
   _____ sand community
   _____ polluted community
   _____ patch reef community
   _____ rocky substrate community

This booklet was prepared by the Education Department, Waikiki Aquarium, with the help of teachers and community members. The following references may help you prepare your students.

Darwin, Charles. 1962. Coral Reefs. University of Californic Press.

Edmonson, C. H. 1974. Hawaii's Seashore Treasures. Petroglyph Press Ltd.

Edmonson, C. H. 1946. Reef and Shore Fauna of Hawaii. Bishop Museum.

Reader's Digest. 1972. Secrets of the Seas. The Reader's Digest Association.

Straughan, Robert P. L. 1968. Exploring the Reef. A. S. Barnes and Co., Inc.

GRADES 8 AND 9
ANIMAL BEHAVIOR

Grades 8 and 9 are introduced to some aspects of marine animal behavior. The Aquarium field trip will be more successful ifteachers prepare their students prior to the visit, and follow the trip with review. This booklet has been prepared to help teachers introduce unfamiliar terms and concepts. Classes involved in the FAST science program may wish to cover animal behavior concepts in more detail, or request topics more pertinent to their area of study. FAST teachers should call the Waikiki Aquarium Education Department (923-4725) with their suggestions.

When you reach the Aquarium, inform the clerk of your arrival. A Docent (tour guide) will greet you,escorting the class to the lecture room. The slide lecture will take approximately 20 minutes. The Aquarium tour time varies, averaging 40 minutes.

The eighth grade normally sees a slide lecture entitled Marine Animal Camouflage which discusses techniques such as countershading: blending, using color, shape and movement, and mimicry. Grade nine views Animal Communication which deals with sending and receiving messages in a water medium.

BACKGROUND INFORMATION FOR TEACHERS:

CAMOUFLAGE

Animals on land and in water use various camouflage techniques. Camouflage is employed by animals for two reasons; 1) to hide from predators, 2) to remain inconspicuous in order to catch food.

One camouflage technique is countershading. Midwater fishes are seen by their predators on more than one plane--above, below and sideways. A countershaded fish has a dark colored back (dorsal) area, and a light colored under (ventral) area. When the fish is seen from above, its dark back blends with the bottom. When seen from below, the light ventral area blends with the silvery surface. Many open ocean fishes are countershaded--mahimahi, tuna, sword and sailfishes. In shallower waters we find reef sharks, ulua and mullet.

Animals also use blending techniques to hide from predators. Blending animals have evolved shape adaptations, which, combined with color, make the animal hard to see. The preying mantis is an example of such blending. Some marine animals found in the Aquarium use this technique. Rock crabs are only detected when they move on the rocks at the water's edge. Sand crabs skim across the sand, their color blending even in motion. Shells like the cones grow blending coverings over their patterned shells. In tidepools we usually do not see blennies or gobies until they dart away.

Motion can be combined with shapes and cryptic colors to make an effective disguise. The brownish leaffish has large fluted fins, giving the overall appearance of a dead leaf. When it approaches a potential meal, it sways slowly with the current, drifting

close enough to swallow the unsuspecting fish.

Mimicry, another camouflage technique, combines shape, color, and sometimes behavior. The study of mimicry is involved, so for our purposes we define a mimic as an animal resembling a specific organism. The anglerfish is both camouflaged and a mimic. The fish's irregular body shape and mottled color allow the fish to look like a rock. At the top of its head the tip of a free fin spine resembles a worm. The angler lies motionless wiggling the worm to attract smaller fish.

Nudibranchs (mollusks without shells) are found in various colors and shapes. Some nudibranchs mimic their food--algae, corals and sponges. The slide lecture shows an example of this technique.

ANIMAL COMMUNICATION

Animals living in water transmit and receive messages in several ways.

Message senders use color, shape, movement, touch, sound, chemical odors, bioluminesence, and electric impulses.

Message receivers use the same five senses humans use to receive with some additions.

Specific animals that will be discussed in the slide lecture or on exhibit in the Aquarium are explained in the following text.

Scientists have determined that many fishes and crustaceans have color vision and are, therefore able to receive color coded messages. Many invertebrates and most fishes can, at the least, see shapes and movements.

Some inedible, poisonous or potentially dangerous animals advertise this condition to other animals by using bright colors. Surgeonfishes draw attention to their cutting blades by framing the blades in contrasting color. The inedible nudibranchs (sea slugs without shells) are often colorful and are easy to spot on the reef. The lionfish, exquisitly patterned and colored, has little to fear, for its poisonous spines are lethal.

An interesting example of animals using bright color, shape, and movement can be observed in the cleaners of the marine community. Cleaner fishes and shrimps eat parasites on fishes and advertise this service.

As in birds, some male fishes and crabs are more colorful than females. The male fiddler crab has a large colorful claw which is used for communication. Certain male species in the wrasse family are more colorful and have larger fins than females.

Several deep sea animals have developed light organs with which they court by flashing their bioluminescent lights on and off. Prey can be lured closer to deep sea predators in the same way.

Methods other than those using the sense of sight can be observed in the aquatic world.

In courtship the sense of touch is employed with bumps and nudges. The onemone crab signals anemones to release their pedal disks by tickling.

Smell can signal messages in the water world. Some animals give off chemical odors when they are ready to molt and mate, or if they are frightened.

Sound carries in water, though the direction of the sound source is not easily determined. Snapping shrimps communicate by making noise with their large claws. Fishes like the menpachi and ala'ihi locate each other by grinding special teeth in their throats to produce sound. Marine mammals such as dolphins and whales are the most advanced sound producers. Different sounds for courting, locating other mammals and finding food have been developed by these mammals.

Electric fish which live in muddy water have developed special electric senders and receptors. The Aquarium's electric eel can send out a charge that kills the fishes on which it feeds. It can also send weak signals to court a mate.

VOCABULARY:

For Classes Viewing the Marine Animal Camouflage Slide Lecture.

predator--An animal that feeds on other animals.
prey--An animal that is potential food for the predator.
coral polyps--Tiny sac-like animals with tentacles, resembling and related to sea anemones.
pigment--A colored substance.
mantle--The portion of the soft-bodied mollusk that makes the hard shell and often contains gills for breathing.
substrate--The ocean bottom.
rubble--Rocks and dead coral loosely piled in an area.
mimicry--Resembling another organism.
camouflage--The art of deception, concealment in the environment.
countershaded--Patterned to blend in with both light and dark areas.

For Classes to View the Animal Communication Slide Lecture.

communication--Sending a message which is received.
caudal peduncle--The part of the fish's body before the caudal or tail fin.
pedal disk--The bottom of the sea anemone which it uses for attachment to rocks.
parasite--An animal or plant which lives on other organisms and feeds on them.
host--An animal on which parasites live.
molt--To shed.

ACTIVITIES:

PRE-VISIT ACTIVITY: For classes to view Marine Animal Camouflage Slide Lecture.

Activity 1

Objective: To observe and apply shape and color blending techniques.

Materials: Teacher's choice of searching and collecting fresh seaweed (algae) taken the day previous and kept in sea water, enough for your needs. Students need drawing paper, pencils, or drawing pens and some form of coloring media.

Precedure: Class members are to pair off, take a few pieces of algae, use magnifying glasses to locate tiny animals hiding among the algae leaves. Draw the animals, coloring them as they are found in their natural state. Name the features that make these animals hard to see.

Extension: Collect beach sand, use a microscope and magnifying glass to find the micromollusks. Describe this camouflage technique.

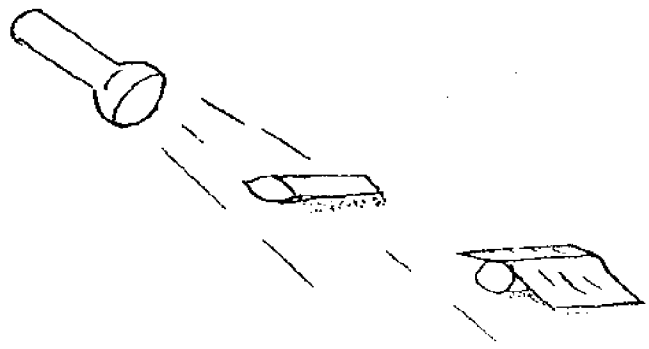
Activity 2

Objective: To understand how shadow reduction is used by animals to avoid detection.

Materials: Empty cardboard rolls 6 or 7 inches long, or toilet paper rolls, heavy construction paper cut into rectangles 5 inches by 8 inches, scissors, glue, and enough flashlights for your class when it is grouped 3 or 4 to a group.

Procedure: Arrange students in small groups, each with a light source. Groups have enough paper rolls, construction paper rectangles, glue and scissors for each member to experiment with. Darken the room, and, using a flashlight, show how the light, when pointed toward a paper roll on a table, creates a shadow. Notice how the shadows change with the angle of the light source. If this paper roll were an animal that didn't want to be detected, what body shape changes could it make that would reduce the shadow? Over thousands of years, some animals have evolved shape changes to accomplish shadow reduction. The rays, squid and flatfish are examples of shadow reduction shapes. Tell the students that they can use the construction paper, or not, doing anything they can to create a shape that casts a small shadow in the sun (flashlight pointed toward the 'fish' at approximately 45 degrees). Give them enough time to exhaust their ideas. If they haven't come up with good results, show them what changes to make.

Desired Conclusion: If the paper roll is semi-flattened, or if construction paper flanges are draped over, the shadow is reduced. This shadow reduction is exactly what the animal needs to avoid detection.



POST-VISIT ACTIVITY: For classes viewing Marine Animal Camouflage Slide Lecture.

Activity 1

Objective: To encourage students to select and observe one animal during the visit.

Procedure: Prior to the Aquarium visit, instruct students to select an animal at the Aquarium that is camouflaged. Observe the animal during the visit. At the next classroom session they will write a few paragraphs about this camouflaged animal using only the knowledge they have obtained before and during their visit.

Activity 2

Objective: To review camouflage techniques.

Procedure: Reproduce the following questions, or discuss them in class.

What camouflage techniques do these animals use--countershading; blending with color, shape or movement; or mimicry.

flatfish	cone shells	blenny
anglerfish	nohu	ulua
lobster	stingray	mullet

For which reason might these animals use camouflage? 1) To hide from predators or 2) To remain inconspicuous or 3) Both.

PRE-VISIT ACTIVITY: For classes to view Animal Communication Slide Lecture.

Activity 1

Objective: To listen to marine animals' sounds.

Procedure: Play any recording or record of marine sounds. This can be obtained from retail music stores, some libraries, or the Save the Whales group. Students are to listen passively, then either write a story inspired by these sounds or draw a picture of images that come to mind.

Activity 2

Objective: To get the students to think about the senses animals use for communication.

Procedure: Class game--discussion. Propose this questions with the possibilities suggested. The class can act out the possibility.

If you were a _____ how would you tell others what you were?

crab	poisonous animal	angry human
opihi	courting bird (peacock)	blade of grass
flower (ginger)	frightened cat	firefly

See if the class can think of other animals and encourage them to use as many different senses as possible.

POST-VISIT ACTIVITY: For classes viewing the Animal Communication Slide Lecture.

Activity 1

Objective: To review marine animal communication techniques.

Procedure: Discuss how the following animals send and receive messages in water.

cleanerfish	electric eel	flatworm
fiddler crab	porpoise	anemone crab
swimming crab	decoy scorpionfish	squirrelfish
		surgeonfish

Activity 2

Objective: To further interest your students in animal communication.

Procedure: Ask your students to research and report on a marine animal which communicates with others which was not included in the slide show.

AQUARIUM TOUR QUESTIONS:

These questions can be assigned for students to find the answers during the Aquarium tour. Because questions for both camouflage and communication concepts are listed, teachers must use only those that apply to their group. In the past, teachers have found that if they assign one or two questions per person, students don't become so preoccupied with finding the answers that they miss interesting points on the tour.

1. Describe how these aquarium animals camouflage themselves. Do they use countershading, color and shape, movement or mimicry?

ghost crab (color)	ray (countershading, shape)
rock crab (color, shape)	flatfish (color, shape, contour)
anglerfish (color, shape, mimicry)	blenny (color, shape, motion)
ulua (countershading)	sea turtle (countershading)

long nosed hawkfish (color pattern [red disappears at depth])

2. The octopus has a unique form of camouflage. Observe it and describe its unusual camouflage technique. If it's not there, read the tank labels and capsulize. (The octopus has versitile color chromatophores that allow instant color changes. Also, the skin surface can be made to appear smooth or textured to blend with surrounding rocks.)

3. Find the cone shell display that discusses how these animals camouflage themselves. Briefly explain. (See Background Information.)

4. The crab exhibit explains how a certain crab decorates its body for camouflage. What crab is this? (The decorator crab, or Maiidae.)

5. Cleaner animals are communicating to others in their tank that they are cleaners. Observe either the cleanerfish or cleaner shrimp. List the methods you see them using to advertise their service. (Bright colors, approaching behavior, antenna movement.)

6. Some male fish are differently colored than females of the same species. Find one example of this kind of color communication, use common not scientific names. (Lined wrasse or red tail wrasse, rose wrasse, most parrotfishes.)

7. Compare the electric eel and electric catfish. Where are the small pores that receive electric signals? (These pores appear around the head area.

This booklet was prepared by the Education Department, Waikiki Aquarium. We feel that the following references will help your students.

Bridges, Wm. 1970. Book of the Water World. American Heritage Publishing Co., Inc.

Hobson, Edmund and E. H. Chave. 1972. Hawaiian Reef Animals. University of Hawaii Press.

Norman, J. R. 1951. A History of Fishes. A. A. Wyn, Inc.

Power, Allan. 1969. The Great Barrier Reef. Paul Hamlyn Pty. Ltd.

The Reader's Digest Association. Secrets of the Seas. Pleasantville, New York.

Wickler, Wolfgang. 1968. Mimicry in Plants and Animals. McGraw-Hill Book Company.

GRADES 10 and ABOVE
AQUARIUM TOUR

Several slide lectures are available upon request. Following is a list of the topics. Call the Education Department (923-4725) to make your appointment and reserve the lecture or lectures you prefer. Appointments for grades 10 and above must be made one week prior to your visit.

When your class reaches the Aquarium, inform the clerk of your arrival. A Docent (tour guide) will greet you, and escort your class to the lecture room. Lectures take approximately 30 minutes, depending on discussion. The Aquarium tour time is approximately 40 minutes.

SOCIOLOGICAL CONCEPTS:

HAWAIIANA - Some legends and uses of fish and fishing techniques of the ancient Hawaiians. (advanced level)

ECOLOGICAL CONCEPTS:

PATCH REEF FISHES - Diurnal and nocturnal activities of patch reef fishes; specifically feeding, fighting and breeding. (advanced level)

SANDY, ROCKY, AND CORAL COMMUNITIES* - Three marine communities, discussing inhabitants, relationships, and habits. (intermediate level, beginning biology)

TIDEPOOL COMMUNITIES* - Two types of Hawaiian tidepools are discussed; inhabitants, characteristics and habitats. (intermediate, beginning biology)

*Lectures are covered in detail in grades 6 and 7 and may be useful as a review.

BEHAVIORAL CONCEPTS:

MARINE ANIMAL CAMOUFLAGE* - Four camouflage techniques exemplified by some marine animals. (intermediate)

MARINE ANIMAL COMMUNICATION* - Sending and receiving messages in a water medium. (intermediate)

DANGEROUS MARINE ANIMALS - Common marine animals dangerous to humans; problems and suggested treatments. (intermediate)

*Lectures covered in detail in grades 8 and 9 and may be useful as a review.

TAXONOMIC CONCEPTS:

ANIMAL PHYLA AND CLASSES - Common Hawaiian vertebrates and invertebrates. (advanced)

FISH FAMILIES - Major Hawaiian fish families; recognizable characteristics. (advanced)

Film loop topics available:

Plankton: Diversity - identification of some plankton.

Larval forms - larval stages of marine invertebrates.

Food webs and feeding relationships - sun's energy converted by photosynthic diatoms who are consumed by herbivorous copepods--on to larger planktonic forms to shoal fishes.

Locomotion: Asterias - tube feet movement.

The Education Department is continually adding and updating their presentation. Teachers seeking information about changes should call the Waikiki Aquarium Education Department (923-4725).

ACTIVITIES:

Suggested topics for student reports.

Marine parks and preserves.
reference: U.S. Department of the Interior.

What can you do with a fish besides eat it?
reference: Suggest imaginative areas, e.g. art, jewelry, deities, products of fishes.

Have you had your seaweed today?
reference: Aquaculture topics.

Shoreline management--Hey, move your condominium!
reference: Local building codes; recent and proposed legislation.

Sea sports and sharks.
reference: Any of many books available.

Poisonous animals--How are their toxins made?
reference: Russel, Findlay E. 1971. Poisonous Marine Animals.
Schultz, Dr. L. P. and Edith Stern. 1948. The Ways of Fishes.

Plankton--If you destroy the ocean's plankton, will you destroy the world?
reference: General zoology books.
National Geographic. July 1952. "Strange Babies of the Sea" (plankton).

Camouflage--Compare land and marine animals, e.g. eyespots, shape and color.
reference: Wickler, Wolfgang. 1968. Mimicry in Plants and Animals.

Conservation--Whose home was that coral head on your table?
reference: Darwin, Charles. 1962. Coral Reefs, University of California Press. Edmonson, C. H. 1946. Reef and Shore Fauna of Hawaii. Straughan, Robert P. L. 1968. Exploring the Reef.

Discuss the various fishing techniques contributed by Hawaii's diverse cultural groups.
reference: MacKellar, Jean Scott. 1956. Hawaii Goes Fishing. Titcomb, Margaret. 1952. Native Use of Fish in Hawaii.

Select one marine animal and one terrestrial animal. Compare the chemical, physical and biological needs of each animal.
reference: General zoology books.

This booklet was prepared by the Education Department, Waikiki Aquarium, with the help of teachers and community members.