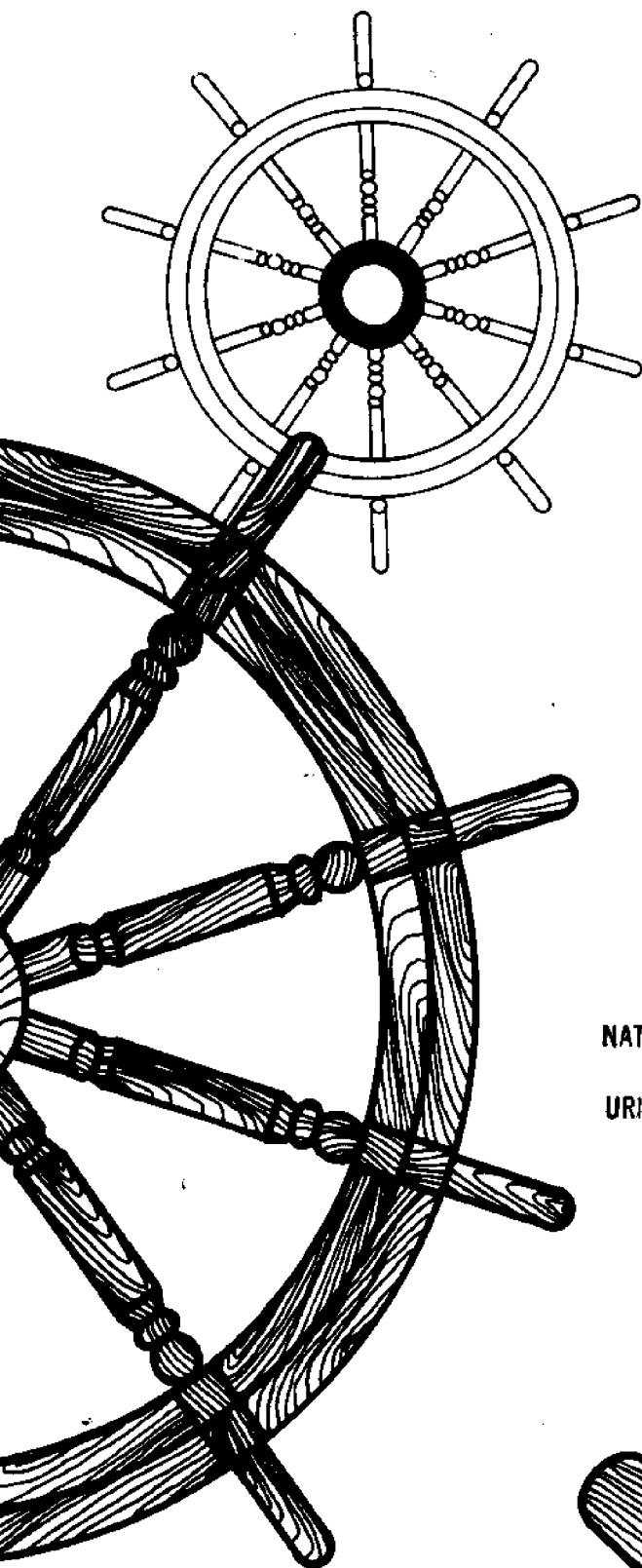


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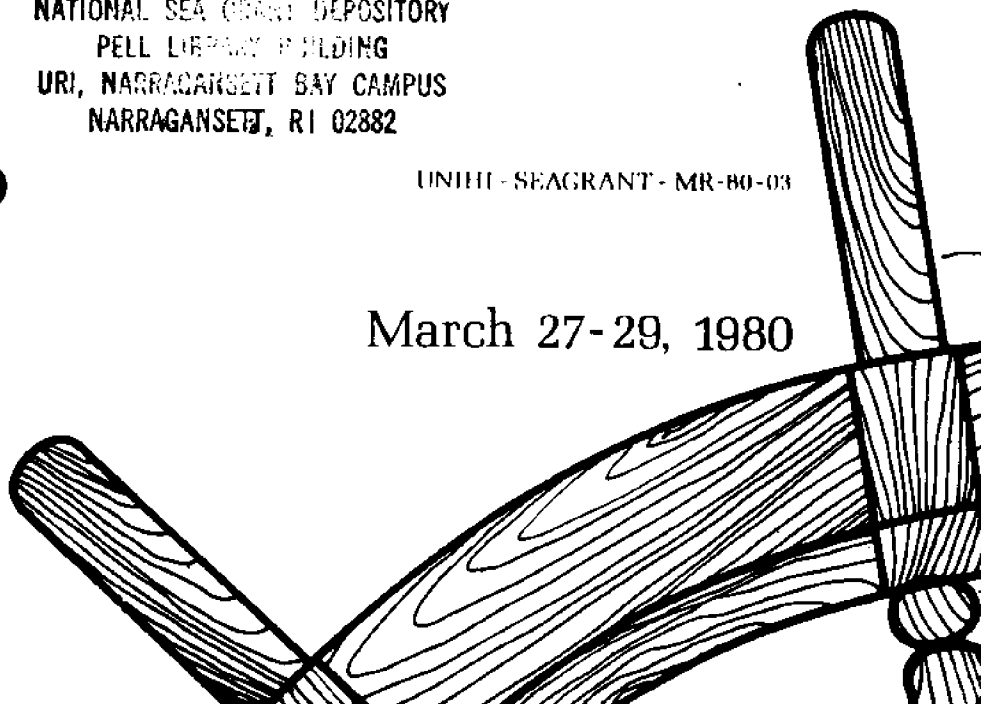


Proceedings of the  
Fifth Annual  
**Student  
Symposium on  
Marine Affairs**

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March 27-29, 1980





PROCEEDINGS OF THE  
FIFTH ANNUAL STUDENT SYMPOSIUM  
ON MARINE AFFAIRS

Sea Grant Miscellaneous Report  
UNIHI-SEAGRANT-MR-80-03

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## PREFACE

This volume of the proceedings of the Fifth Annual Student Symposium on Marine Affairs, which will be held on March 27-29, 1980, at the University of Hawaii Hilo campus, contains thirty-eight papers in ten categories: marine biology I, marine biology II, aquaculture, energy, economic potential of the ocean, manganese resources, marine mammals, heritage of the sea, engineering, and ocean law and policy.

We have not attempted to edit the papers but wish instead to give credit where credit is due, to the forty-three students whose papers were selected and their teachers.

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Trevor Jackson  
Colleen Shikuma

Ms. Merle Yao



Because 89 papers were submitted to the Fifth Annual Student Symposium on Marine Affairs, it was impossible to include them all for presentation at the symposium and in the proceedings. We do feel, however, that the authors of the papers that were not included deserve recognition in this volume. Therefore, their names and schools are listed below.

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We gratefully acknowledge the support and cooperation of the Office of the Marine Affairs Coordinator and the State Department of Education.

Rose Pfund, Coordinator  
Student Symposium on Marine Affairs



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# Marine Biology I







OPIHI  
by Leighton Ikeda and Patrick Aniban, Pahoa High School

ABSTRACT

Along the rocky shorelines of the Hawaiian Islands, there has long been a delicacy to the people of Hawaii. This delicacy is better known as opihi. My partner and I have chosen to do a research paper on the opihi because we thought it would help you get better acquainted with this species that has been with us for a long time.



## OPIHI

### Introduction

To start off our report on opihi, we would like to get you acquainted with the two major types of opihi that we will be discussing. The first type is the black foot (*Cellana exarata*) and the second type is the yellow foot or (*Cellana Sandwicensis*). The black foot is better known as the lazy man's opihi because it is found higher up along the shoreline than the yellow foot. The color of the species is blackish and it is said to be really tender. The yellow foot is found below the black foot where there is constant spray from the waves, and this location of the yellow foot has caused many Opihi pickers to suffer injury or even the loss of life. I often wonder why so many people would risk their lives for the opihi. I guess there are lots of reasons; mostly its part of life. The color of the yellow foot is yellowish and the texture of its meat is rather crunchy. The opihi is not only delicious but it is also high in protein. Therefore, we will be discussing its habitat, feeding, growth rates, maturation, and spawning later in this report.

### Habitat

Opihi are almost entirely restricted to basalt shorelines in the Hawaiian Islands. *Cellana exarata* or black foot can be located to both vertical and horizontal distribution, because of this I think most of you have seen opihi (black foot) on shorelines of all the windward islands. *Cellana sandwicensis*



(yellow foot) is also common along shorelines of all the windward islands.

*Cellana exarata* is found higher on the shoreline, extending from the spray zone to the seaward benches where it usually mingles with the sea cucumber. The black foot does not associate with the seaward benches where the substrate is thickly encrusted with algae and where there is constant wave splash, nor is it found near the tide mark. The black foot has a great ability to raise its shell and ventilate its mantle cavity, which enables it to live in a more fluctuating environment than the yellow foot.

*Cellana sandwicensis* or yellow foot is found on coralline algae or areas of basalt bench where there is lots of algae, constant wave splash and spray from the waves at low tide. It is said that some sea urchins feed on the yellow foot but predation does not appear to be common enough to cause the opihi to become an endangered species.

### Feeding

The black foot feeds on the higher areas of distribution on which it leaves feeding scars, just as insects leave scars on fruit or plants. Feeding scars are indicated by clusters of animals which persist from week to week pebbles or flat rocks and by its grazed areas around the shells. The scars they leave behind are not deep, but merely grazed sections of the substrate. The black foot usually feeds on incoming tides during the day and at night during low tide. As soon as dawn breaks they move



from their homesite and return to it when the sun comes out and the rocks dry out. They hardly make any movement when the rocks are hot and dry during the day, but the spray from the ocean or the rain are adequate to initiate movement of the black foot. This has proven that they move more when feeding on cloudy or rainy days and on lower reaches of the shore than on sunny days or in the spray zone. Their diet consist of diatoms, calcareous algae and blue green algae.

The feeding scars of the yellow foot usually consist of oval impressions in the coralline algae substrate on which they were found different from the black foot with which the basalt is not eroded away. Movement of the yellow foot also occurs when spray, the incoming tide starts to wet them, and at night. Their diet consists primarily of calcareous algae and any algae thats available.

#### Growth Rates

Growth rates between the yellow foot and black foot, there is no significant difference. Both of them show rapid growth shell. They usually increase from 4 to 5 mm per month in length, up to 20 mm. After 20 mm to 30 mm their growth rate decreases from 4 to 5 mm to 2 to 3 mm per month. It remains this way until they are at least 50 mm in length. One main factor for their decline in growth after 20 to 30 mm in length is sexual maturity. However, as the growth of the length of the shell slows down after sexual maturity, the increase in body weight continues to increase throughout it's life. As I mentioned earlier, the growth



rates of the two species are not significantly different. However, there is a difference between their body weight and their shell weight. The black foot has a heavier body weight than its shell. The yellow foot is just the opposite, a heavier shell than its body weight. One possible explanation for this is that the yellow foot is associated with an area of breaking waves and is being constantly pounded, where a heavier shell would assist in protection. Opihi grows very rapidly and can reach up to 40 mm (1.6 in.) in one year.

#### Maturing and Spawning

The opihi is determined to be mature at a certain size. At 2 mm, about 50% of opihis are sexable, this was defined to be the smallest size class. As they mature, they begin to start to reproduce and spawn.

#### Spawning in *Cellana Exarata*

The mature ovaries are yellow and the testies are tan. Fertilization is external and the larvae settles about 3 to 4 days after fertilization. The study on how the larvae is developed has not been done yet. The matured opihis are never spawned out, they are capable of spawning throughout the whole year. Spawning occurs most plentifully in the months of March through June, and from September through December.

In *Cellana sandwicensis* (yellow foot) seems to spawn most plentifully in the months of March through May, and July through August and November. Settlement was highest in February, March and June. Settlement and spawning in both species are concentrated



very highly in those months of the year when the sea temperatures are the lowest and wave action is variable.

### CONCLUSION

Because the opihi has been a delicacy to the people of Hawaii for a long time, we hope the people of Hawaii will try to preserve and increase this species for our future generations so they can see what this land of ours can provide. We hope that this report has given you a better view of the opihi.

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JELLYFISHES  
by Blanche Iwashita and Karen Yeargain, Pahoa High School

ABSTRACT

This symposium paper will go over the various types of jellyfish. It will discuss the way they eat and how they catch their prey. During Richard Hawkins' journey to the Azores in 1590 he saw many different sizes and shapes of jellyfish. The smallest jellyfish ever seen in Hawaii is less than one-half inch long. The reproduction is unlike any other sea creature of the deep seas. The contents of the jellyfish is 96% of water and almost 4% of albumen.



## INTRODUCTION

In this research of the jellyfish, my partner and I have found out about their many descriptions and their appearance all over the world. They were seen in 1590 by a man named Richard Hawkins, an Elizabethan sea captain. In some species we also have found that both their sails and tentacles are dangerous. The effect of their sting is most unbearable.

The reproduction of the jellyfishes is most unique. Their transportation is by the currents and they travel out to the sea and also can be seen close to the shores. We have chosen to do a symposium paper on jellyfish to find out about their description and their dangers.



The Hawaiian Portuguese man-of-war; has a brightly colored float only about two inches long and somewhat pointed at both ends. The upper part of the float is filled with gas, which keeps it on the surface. Many tentacles hang down in the water from the underside of the float. Some of the shorter ones have mouths and take in food. The longer ones are like a narrow ribbon. One of these is longer than the others and may extend down in the water a foot or more.

On one edge of the narrow ribbon is a row of "Batteries" carrying a powerful stinging cell. They discharge darts with enough force to penetrate a person's skin. The fluid injected raises welts and causes discomfort for some time. These jellyfishes can get food by stinging small animals and drawing them up to its many mouths by the tentacles.

Large jellyfish are usually found floating on the surface of the sea, or washed ashore by the current.

The huge sea blubber grows to be seven feet across the disk, with tentacles one hundred and twenty feet long. There is no other species as large as this. One of the pelagia group is sometimes two feet or more in length. The North pacific variety reaches a diameter of one and a half feet. These animals are large and heavy but not more than five percent of the body is solid.

Jellyfish can be preserved with a mixture of alum and salt or between the steamed leaves of a kind of oak.

In some species, there are one or two tiny eye spots. These tiny organs are protected by a small hood or fold of the



umbrella margin. The umbrella margin may be globular, disclike, conical, cubical, or divided by a circular groove.

The stomach activity extends out toward the margin of the disk in a number of pouches that are connected to a ring canal of the umbrella, but in some cases, the canal may be absent.

The eggs and sperms are passed through the mouth, the eggs are fertilized in the water and may remain in pouches in the manubrium for a part of their development. In pelegia, the development is totally direct.

There are smaller jellyfish known as "sea rafts" that float on the ocean and sometimes come close to shore. There is a bluish-green jellyfish called velella, which means a sail. It has a flat body with a fringe of tentacles about the edge, and a thin sail on top.

Bell-shaped jellyfish are occasionally seen in shallow water. Most of them seem to avoid the rocks of the reef and the danger of being blown ashore.

The smallest jellyfish seen in Hawaii is less than one-half inch long. The jellyfish cannot swim and is attached to seaweed by a stalk that grows out of its back.

Jellyfish feed mainly on small invertebrates of different kinds which are trapped by the tentacles and paralyzed by the nematocysts of the tentacles and oral lobes, then they are carried to the mouth.

Jellyfish have extremely high proportion of water in their body tissue, usually in the form of jelly. They may consist of as much as ninety six percent water.

The first Englishman to write about the jellyfish was a



man by the name of Richard Hawkins, an Elizabethan sea captain.

"I saw in 1590, lying with a fleet of her majesties ships about the iselands of the Azores, almost six month's, the greatest part of the time we were becalmed, all the sea so replenished with several sorts of jellyfish, and forms of serpents, adders, snakes as seemed wonderful; some green, some black, some yellow, some white, some of the diverse colors; and many of them have life, and some there were a yard and a half and two yards long; which had I had not seen, I could hardly believed. A man could not draw a bucket of water clear of some such life".<sup>1</sup>

In short : When Richard Hawkins, in 1590 was at sea with a fleet of ships around the iselands of the Azores, for about six months, he discovered the calm sea surrounding him full of jellyfish, and forms of serpents, adders and snakes. He noticed that the jellyfish were at least a yard and a half, to two yards long.

If you watch a jellyfish swimming either in the sea or in a glass container, you will find that small jellyfish pulse rapidly, large ones more slowly.

During much of the summer, jellyfish drift offshore, sometimes assembling in hundreds along the line of meeting of two currents, where they trace winding lines on the otherwise invisible boundaries.

It is important that jellyfish swim more or less upward toward the ocean surface. Even though they may not sink at all



when still, they are such active swimmers that they are in danger of swimming downward into the dark, deeper water where little food exist, and death awaits. So, they are equiped with sense organs that guide them away from the darkness below.

A tide pool is a good place for budding in animals, and even to perform a few experiments. Sea anemones often reproduce simply by dividing in two, from the base, to the crown of tentacles. Some species multiply more rapidly, however, by pinching off a whole ring of small buds from the flat, muscular base. Each fragment then grows into a miniature of the original anemones and gradually increase to full size.

Certain individuals budded off are not polyps, but tiny jellyfish that swim away. In this fashion, normally a sessile colony, is distributed over a wide area. The off spring of the jellyfish, which reproduces sexually, later settles to the bottom and grows into a new hydroid colony.

This is called alternation of generations, for one generation reproduces sexually, the next by budding. The hydroid then has the advantages of each kind of reproduction.



### conclusion

During much of the summer time, jellyfish have been drifting off shore, sometimes assembling in hundreds along the line off meeting of two currents where they trace winding lines in the sea, the otherwise invisible boundaries. Jellyfish feed mainly on small invertebrates of different kinds, which are trapped by the tentacles and paralysed by the nematocysts of the tentacles and oral lobes, then they are carried to the mouth.

The Hawaiian portuguese man-of-war, has a brightly colored float only about two inches long and somewhat pointed at both ends. Certain individuals budded off are not polyps, they are tiny jellyfish that swim away. In this fashion, the hydroid, normally is a sessile colony is distributed over a wide area.

On one end of the narrow ribbon is a row of "batteries" carrying powerful stinging cells. The discharge darts, have enough force to penetrate through the skin. The fluids injected raises welts and causes discomfort for some time. They can get food by stinging small animals and drawing them up to its many mouths by its tentacles.

This paper will go over almost everything books have to offer about these jellyfishes.



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THE EXPLANATIONS OF CRUSTACEA  
by Leslie Kaholoaa, Pahoa High School

**\*\*ABSTRACT\*\***

Of all the living creatures of the sea, crustaceans have always fascinated me the most.

Sometimes while I am at the beach catching these remarkable creatures, I am sometimes asked questions about them by nature lovers, amateur scientists, teachers and students. That's why I feel it is important for me to construct this handbook to serve as a guide for the interested people as well as myself.



## INTRODUCTION

Crabs, lobsters, shrimps, etc. combined, form a very large group of animals known as the crustacea. The crustacea in turn make up one of six groups or classes which together form one of the principal groups of the animal kingdom known as the artropoda or arthropods.

The arthropods are the largest phylum or group, in the animal kingdom and include well over a million different kinds of animals. Within this phylum of the arthropods, the insects are by far the largest class. Since they include about 900,000 kinds, they outnumber all the other kinds of animals combined.



## ANCESTRY

The arthropods, including the Crustacea, have been living on the earth a very long time. Scientists think that they have been here at least 500 million years, for they find their remains in the ancient rocks of the Cambrian period, which dates to the very earliest times of the Paleozoic era. But even so, the arthropods must have come from some other ancestor. Biologists are not sure, but they suspect that the arthropods may have originated from the annelid worms, for they resemble these worms somewhat and have a rather similar nervous system.

If the arthropods arose from the annelid worms, they made some rather important improvements in their body. They developed a more centralized nervous system, hardened the outer layer of the body into an outside skeleton or exoskeleton, and developed jointed legs. Let us now see what kind of a body these arthropods developed.

## BODY STRUCTURE

The arthropods, including the Crustacea, have an exoskeleton covering their bodies. This outer covering is composed of a horny substance called chitin and is made hard and firm by the addition of lime. This outer skeleton is not one continuous piece, but is divided into a series of sections or segments called somites. These ring like somites encircle the outside of the body and contain the organs inside. These somites are usually grouped into regions to form the head, the thorax and the abdomen; often, as in most Crustacea, the head and the thorax are further combined into a cephalothorax.



## CIRCULATION

The blood of Crustacea, although nearly colorless, serves the same purpose as the blood of man--to carry the supply of food and oxygen to the tissues and to remove the soluble waste materials.

This blood is distributed by a single pulsating heart in the dorsal part of the body. In the lobsters the heart discharges blood to the various organs and tissues. The blood in Crustacea is not as rigidly contained in vessels as in the bodies of the mammals and other vertebrates, and it tends to flow more freely, bathing the tissues which it supplies. It then seeps back to the gills and to the heart.

## RESPIRATION

Crustaceans obtain their supply of oxygen by means of gills. If the animal lives on land, the gills are kept moist, and the oxygen is drawn from the air by these gills and then passed on to the blood stream. If the animal lives in the water, the oxygen supply is taken by the gills from the dissolved oxygen in the surrounding water. These gills are feather-like in appearance and are to be found in two or three rows on either side of the body beneath the carapace or shell. Water is passed through these gills from back to front by the bailing motion of the appendages.

## GROWTH

Crustaceans cannot grow as many other animals do because their outer skeleton will not stretch. To overcome this they periodically shed the outer skeleton, grow rapidly for a short time, and then form another hardened exoskeleton. To accomplish this change of clothing,



they retreat to an isolated place wher they feel they will not be attacked while their skeleton is soft and they are helpless. They begin this change by withdrawing much of the lime from their skeleton; then they shrink a bit to loosen the outer "shell"; thereafter they back out through a crack on the dorsal side between the carapace and the abdomen. As they emerge from their old "shell", they pull out not only their body, but the legs, antennae, eyes and all of the other appendages. The animal is now free to grow, but it is doft and weak. It immediately begins to expand to a new and larger size by absorbing water. Thereafter it will redeposit lime into its outer coat until it is again hard and firm.

I shall also add that crustacea have two other remarkable abilities. The first of these ability is to willfully break off or drop their appendages. The second ability is to regenerate.

#### HABITS, HABITAT, AND MODE OF LIFE

Crustacea vary widely in their habits and in the habitat in which they live. Some live in the ocean, some in fresh water, and some on land. Some are free living, some are commensals and live jointly, associated with other animals, and some are parasitic. Their food also varies widely; some eat plants, some eat flesh, and some are bottom feeders living off anything which they can find. Many are nocturnal in their habits and spend the day hidden away in a burrow, buried in the sand, or esting in a crevice usually with their front end facing out to protect themselves.

Crustaceans move by walking and by swimming. Most of them have the ability to move in all directions, although each species has its preferred method of walking. When frightened, some will resort to swim-



ming which they do either with their legs or by downward strokes of their tails, depending upon the species. Other species, including the parasitic forms, may move very little after they become mature.

#### EATING AND DIGESTION

In the Crustacea, food is usually caught in the pinchers, with the aid of the maxillae and maxillipeds, and held in front of the mouth or put into the mouth. Food entering the mouth passes through the jaws or mandibles, then through a short esophagus and on into a large cardiac stomach: from there it goes into a gastric mill with its ossicles to be ground. The food then passes into the pyloric stomach and on into a many-lobed digestive gland where it receives the various digestive fluids and hence digestion and absorption continue as the food passes along the intestine. The undigested food and other remnants of material taken into the mouth then pass on out of the body.



## CONCLUSIONS

### THE IMPORTANCE OF CRUSTACEA

Crustacea are both beneficial and harmful to man and are therefore of importance to him. They constitute a large amount of food in the form of shrimps, crabs, and lobsters. They are also the basic food on which most large fishes and whales live, for the smaller Crustacea feed upon floating plants in the sea and are in turn eaten by larger and larger fish. Because of this we say that they form an important link in the food chain in the sea. Crustacea are also helpful in keeping water clean; they eat great quantities of decaying material and also act as scavengers in nature.

Although Crustacea are helpful, they also do much harm. They devour wooden pilings, ship hulls, and other wood in water. They also assist in the transmission of some of man's diseases. Man, however, is learning to control these problems so that today Crustacea are much more helpful than harmful to man.



A COMPARATIVE STUDY OF THE UNIQUENESS OF MALE AND FEMALE HORMONES  
IN THE SANDCRAB *OCYPODE LAEVIS* (DANA)  
by Russell Taira, Aiea High School

ABSTRACT

Previously it was found (by this author, 1977) that the eyestalk of the sandcrab, *Ocypode laevis*. (Dana), produced substance which are necessary for activity. Since death in many crabs resulted when the source of this substance was removed, it was deemed logical to believe that other factors are apparently involved. Male and female crabs were tested separately in search of factors which may be involved in male and female systems.

To obtain the necessary data, many tests were conducted separately for both male and female crabs over a 24 hour period of 12 hour light 12 hour dark. Comparisons of data in terms of average lengths of activity were made for: (1) normal crabs biorhythm; (2) ablated crabs (eyestalks removed); (3) concentration of eyestalk substance; (4) inter-changeability of hormones between sexes and; (5) effect of energy levels in the function of activity substance.

Validity was established through t-test of statistical analysis and was accepted if the probability was 0.05 or better.

Significant results showed; (1) that there is a difference between male and females in average length of activity and biorhythm; (2) that this activity is caused by substances from the eyestalk; (3) that the concentration of activity substance is important for normal activity; (4) that the eyestalk substance necessary for activity is similiar in both males and females; (5) that female eyestalk substance contains a second substance which is uniquely different from male eyestalk extract; (6) that this second substance is absent in males; (7) that the second substance is vital to life in female but deadly to male systems; (8) that the activity



substance in both males and females control the activity of organs within organism; (9) that increased energy levels stimulate processes controlled by the activity substance and not the substance found only in females.

## INTRODUCTION

According to the literature (Barne, 1968) eyestalk hormones control the color of the crab (by contracting the chromatophores) and inhibits various physiological processes (eg. molting). The same eyestalk substance may also control the biorhythm. My experiments (1977) showed that eyestalk substances are necessary for stimulation of activity in the sandcrab, Ocypode laevis, (Dana).

Previously it was found (by this author, 1977) that the eyestalk of the sandcrab, Ocypode laevis, (Dana), produced substances which are necessary for activity. Since death in many crabs resulted when the source of this substance was removed, it was deemed logical to believe that other factors are apparently involved. Male and female crabs were tested separately in search of factors which may be necessary for life. Since separate tests of male and female crabs showed statistically different results, it was concluded that different factors may be involved in male and female systems.

## OBJECTIVES

The objectives of these investigations are as follows:

1. To determine the normal biorhythm of both male and female sandcrabs, Ocypode laevis, (Dana).
2. To determine the average lengths of activity for both male and female sandcrabs.
3. To determine if there is a difference between male and female sandcrabs average lengths of activity and biorhythm.



FLUORESENT  
LIGHT

ON/OFF  
SWICH

4 CHAMBERS

4-CHANNEL  
RECORDER

THERMOMETER

POWER SOURCE

DAY/NIGHT  
TIMER





4. To study the mechanisms (of both male and female sandcrabs) which controls the maintenance of normal activity levels in the sandcrabs.
5. To determine if activity substances control activity of organs.

## PROCEDURE

### CONSTRUCTION OF ACTIVITY CHAMBERS

The activity chambers, in which the tests were conducted, were constructed in a light-proof cabinet (see Diagram W., opposite page.) Each chamber was made so that the crabs' movements would activate the recording mechanism.

Data was recorded for 24-hour periods on a Rustrak 4-channel recording system.

A fluorescent light, set to go on and off at designated times of the day, was mounted in the cabinet to simulate day/night conditions.

## PROCEDURE

### Test 1

Three (3) male crabs were placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

### Test 2

Three (3) female crabs were placed into individual chamber and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

### Test 3

Three (3) male crabs were ablated (eyestalks were removed and the wounds cauterized to stop the bleeding) and placed into individual chambers. They were then monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

### Test 4

Three (3) female crabs were ablated (eyestalks were removed and the wounds



cauterized to stop the bleeding) and placed into individual chambers, they were then monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 5

Three (3) male crabs were injected with 0.01 mls. of male hormones. The crabs were then placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 6

Three (3) female crabs were injected with 0.01 mls. of female hormones. The crabs were then placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 7

Three (3) male crabs were injected with 0.01 mls. of Van Harreveld's solution. The crabs were then placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 8

Three (3) female crabs were injected with 0.01 mls. of Van Harreveld's solution. The crabs were placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 9

Three (3) male crabs were ablated (eyestalks were removed and the wounds were cauterized to stop the bleeding) and injected with 0.01 mls. of male hormones. The crabs were then placed into individual chambers and then monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 10

Three (3) female crabs were ablated (eyestalks were removed and the wounds were cauterized to stop the bleeding) and injected with 0.01 mls.



of female hormones. The crabs were then placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 11

Three (3) male crabs were injected with 0.01 mls. of Dextrose. They were then placed into individual chambers and were monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 12

Three (3) female crabs were injected with 0.01 mls. of Dextrose. They were then placed into individual chambers and were monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 13

Three (3) male crabs were injected with 0.01 mls. of caffeine. Then the crabs were placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 14

Three (3) female crabs were injected with 0.01 mls. of caffeine. Then the crabs were placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 15

Three (3) male crabs were ablated (eyestalks were removed and the wounds were cauterized to stop bleeding) and then they were injected with 0.01 mls. of female hormones. The crabs were then placed into individual chambers and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

#### Test 16

Three (3) female crabs were ablated (eyestalks were removed and the wounds were cauterized to stop the bleeding) and then they were injected with 0.01 mls. of male hormones. The crabs were then placed into individual chambers

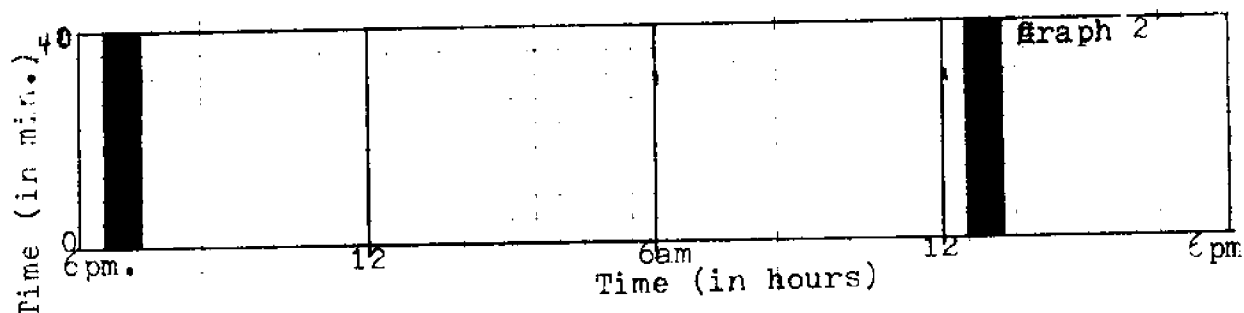
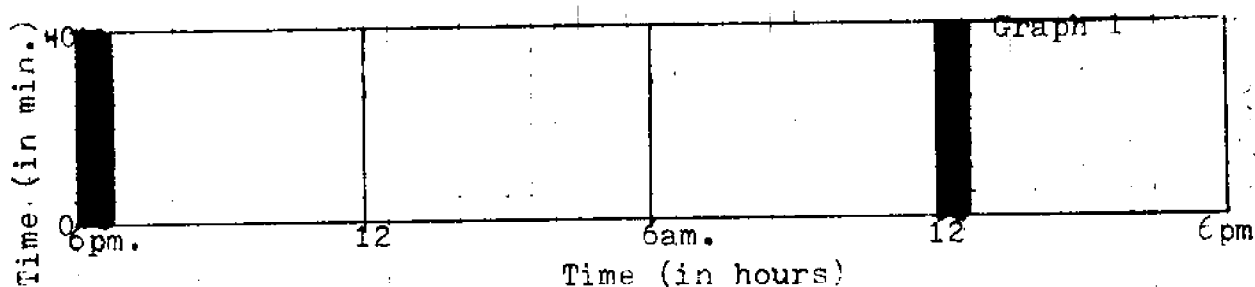


and monitored for a 24-hour period of 12 hours of light and 12 hours of dark.

### DISCUSSION

For each test, activity periods of three crabs were monitored for 24-hour periods (12 hours of light and 12 hours of dark). Data was collected and averaged in terms of total lengths of activity and time of activity. They were compared between male and female crabs.

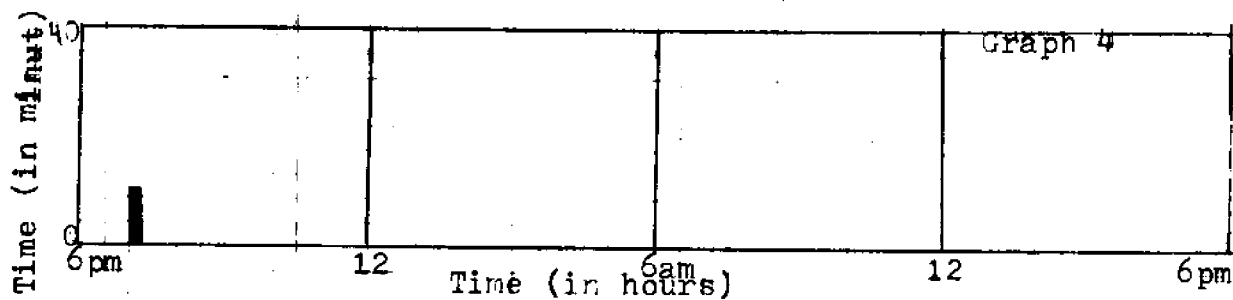
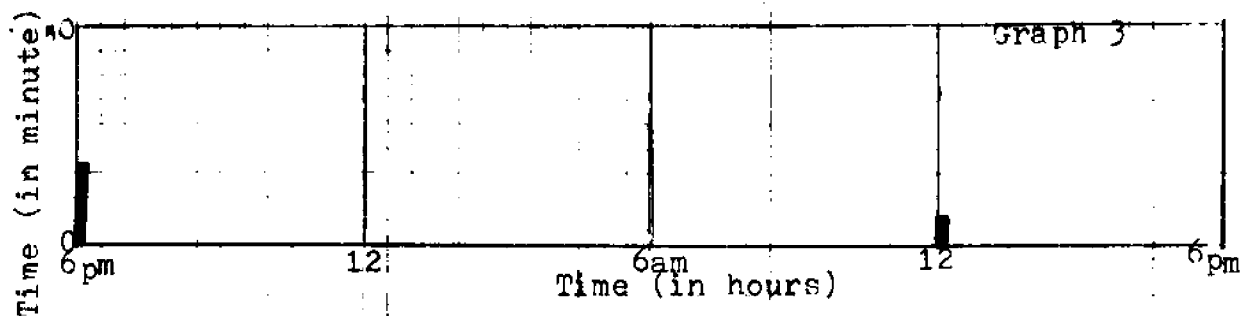
Control data observations of male and female crabs were compared from data collected. Results showed (see Graph 1 & 2) that there is a difference



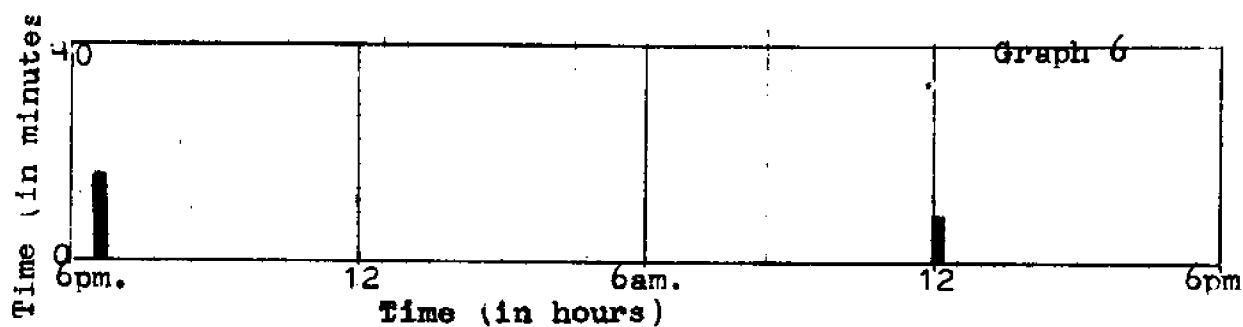
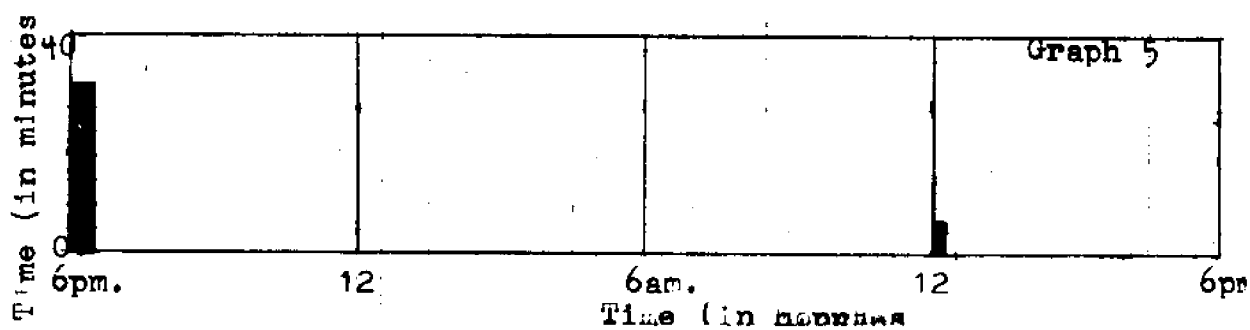
in average lengths of activity and biorhythms. Therefore it was concluded that there is a difference in average lengths of activity and biorhythm.

When ablated male and female crabs were compared, results showed (see Graph 3 & 4) that there is a difference in average lengths of activity and biorhythm. When ablated crabs were compared to normal crabs, results showed that there is a significant decrease in average lengths of activity and a



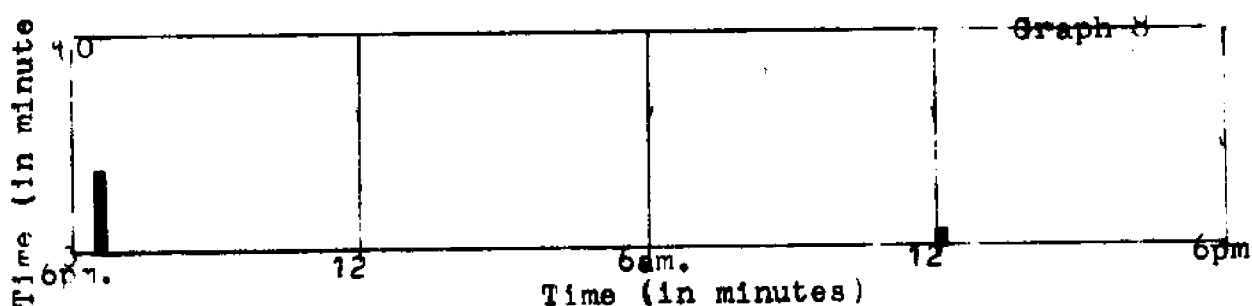
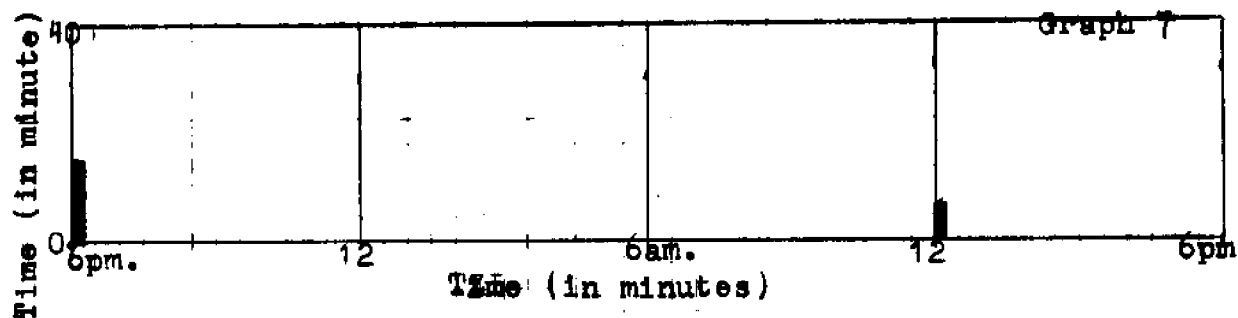


change in biorhythm. Therefore it was concluded that eyestalk substances are necessary for normal lengths of activity, but is vital to females. Further results showed (see Graph 5 & 6) that when concentrations of eyestalk substances are restored activity is restored, (ablated crabs injected with 0.01 mls. of eyestalk substance).



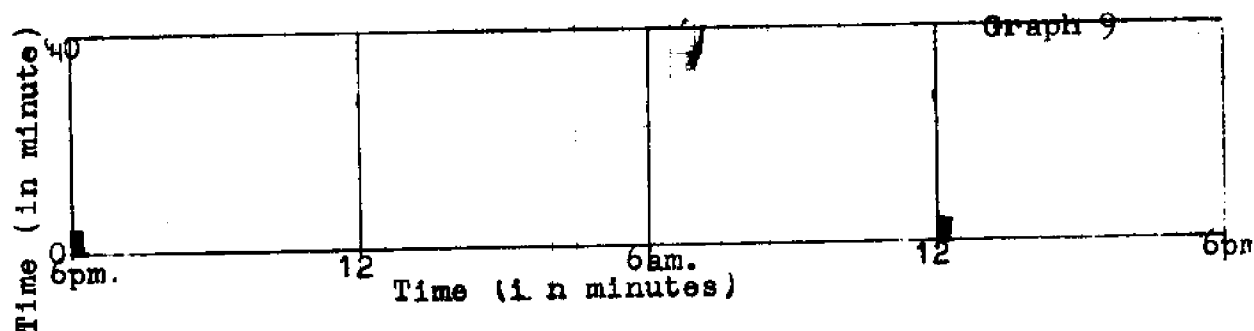


When data for normal male and female crabs which were injected with 0.01 mls. of eyestalk substance were compared to data for normal crabs, results showed that (see Graph 7 & 8) over concentration of eyestalk

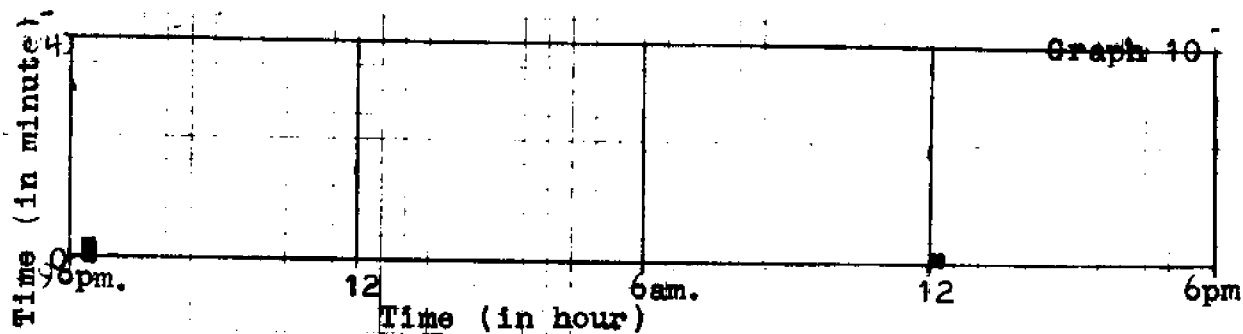


substances, decreased activity. Results also showed that there was a significant difference when activity was compared to normal crabs. Therefore it was concluded that the concentration of eyestalk substance is important for normal function for male and female crabs.

When normal male and female crabs were injected with 0.01 mls. of Van Harreveld's solution were compared to normal crabs, results showed that (see Graph 9 & 10) there was a significant decrease in activity. Thus

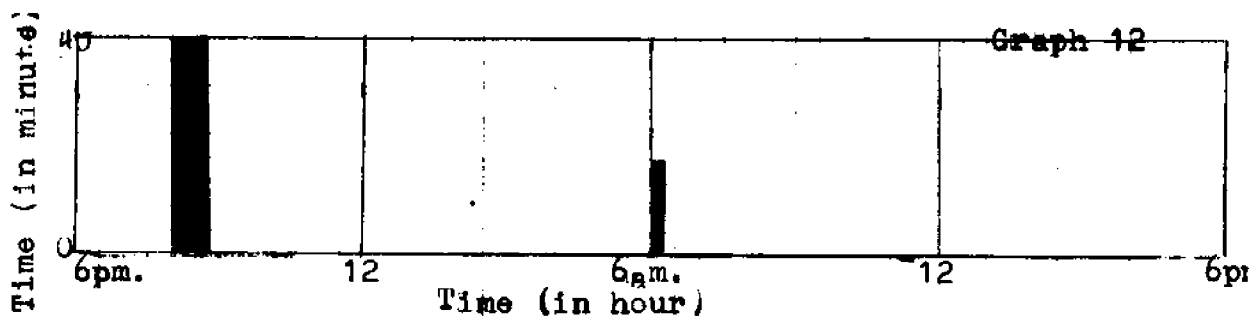
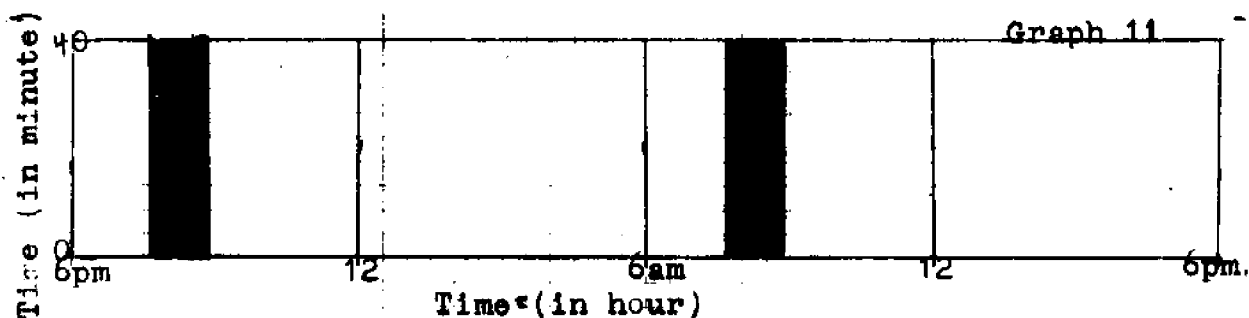






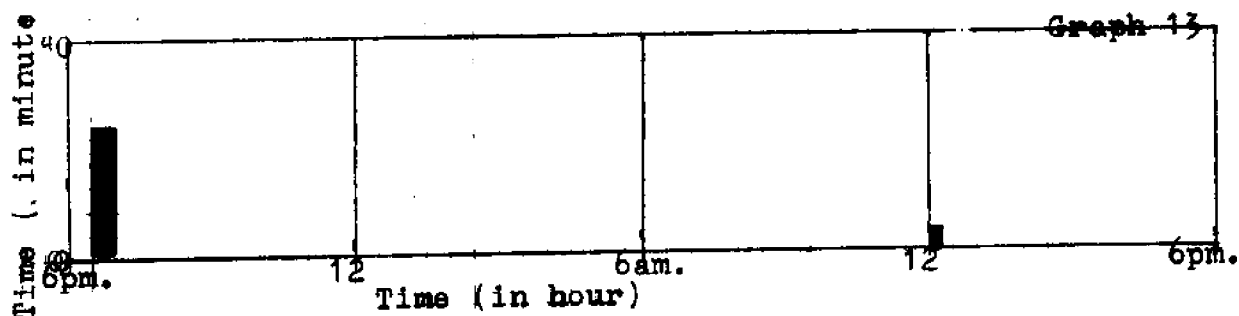
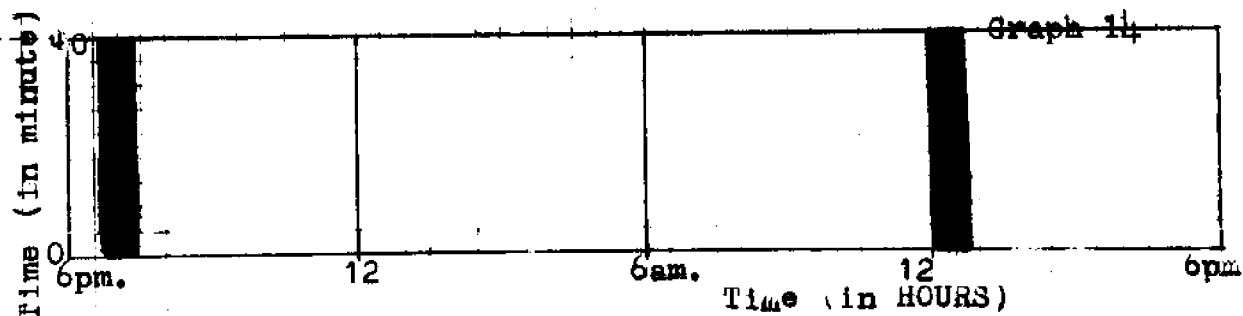
addition of this substance causes dilution of concentration of eyestalk substances and decreases activity.

When normal male and female crabs were injected with 0.01 mls. of destrose were compared to normal crabs, results showed that (see Graph 11 & 12) this substance increases activity in both male and female crabs. Therefore it was concluded that male and female crabs have a special activity.



When ablated male crabs were injected with female hormones and female crabs injected with male hormones were compared, results showed that (see Graph 5 & 13) ablated male crabs injected with female hormones exhibited decreased activity and also death. Results showed that ablated females





injected with male hormones caused an increase in activity as compared to ablated female injected with female hormones, (see Graph 6 & 14).

#### CONCLUSION

In conclusion, the data shows: (1) that the normal biorhythm for the male sandcrab is at 6 p.m. and 12 p.m. and the female sandcrab's normal biorhythm is at 6:30 p.m. and 12:30 p.m.; (2) that the average lengths of activity for male is 41 minutes at 6 p.m. and 12 p.m. and the female's is 36 minutes at 6:30 p.m. and 12:30 p.m.; (3) that there is a difference between males and females in average lengths of activity and biorhythm; (4) that this activity is caused by substances from eyestalk; (5) that the concentration of activity substance is important for normal activity; (6) that the eyestalk substance which is necessary for activity and is similar in both male and female crabs; (7) that female eyestalk substances contain a second substance which is uniquely different from male eyestalk extract; (8) that the second female substance is vital to life in females but deadly to



the male's system; (9) that this second female substance is absent in male crabs; (1) that activity of organs is maintained by the activity substance in both male and female crabs.

Therefore:

Male eyestalk substance contains-Activity substance A

- 1) Maintains lengths of activity
- 2) Maintains time of activity
- 3) Maintains activity of organs
- 4) Dependent on concentration

Female eyestalk substance contains-Activity substance A

- 1) Maintains length of activity
- 2) Maintains activity of organs

Activity substance B

- 1) Maintains time of activity
- 2) Influences lengths of activity

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# Marine Biology II







MARINE SCIENCE: ITS PRESENT AND FUTURE STATUS  
by Graciela Cuellar, Waiakea High School

I have tried to show in this paper how a knowledge of marine biology bears on human affairs. It is essential for the management of our food resources, and necessary to guard against pollution of the sea, and maintain, and conserve some species and their environment.

The most obvious field is that of food from the sea. It is now estimated that we receive nearly a hundred million tons of fish a year. The seas were thought to be inexhaustible. Scientific observations led to the conclusion that no serious damage could be done by commercial fishing, when in fact beam trawling by steam vessels was destroying the spawning grounds of commercially important fish.

Many fisherman thought that marine fish laid their eggs on the seafloor or attached to weeds or rocks. But a Norwegian naturalist, G.O. Sars had shown that the eggs of cod and grunards were planktonic, being spawned in the upper waters far above the seafloor. So marine laboratories studied early life histories of fish in the sea and described their egg and yolk stages so that their distribution could be plotted.

Increasing numbers of fishing vessels and advances in the efficiency of gear were evidence for danger of overfishing. Since the war, studies have been done on the problems of the estimation of fish stocks and their rates of recruitment. Some species are becoming seriously overfished. This may subside if the countries bordering the sea will have sovereignty over their own areas. It might enable greater management of stocks, but it may restrict the operations of research vessels because, already, permission is now needed to visit waters controlled by other countries. The problem of stock management requires a great deal of investigation to find the effects of fishing on the recruitment of each species and the relationship between one species and other competing species and with the ecological environment.



But the supply of food from the sea, even if well managed, is not inexhaustible. To some extent it can be supplemented by the farming of fish and shellfish in confined areas.

The cultivation of marine fish has been difficult. The main problem was that most sea fish hatch at a very small size, usually about 3mm long, and have extremely small mouths. When they have absorbed their yolk, they are still not able to capture and eat tiny organisms. It was found before the war that brine shrimp lay a vast amount of eggs perfect for a food source for cultivating fish.

Many fish can be harmful to eat. From time immemorial people have been warned against poisonous species. An ancient Jewish rule that fish with no fins or scales should not be eaten. The puffer fish was recognized as poisonous in the times of the Pharaohs. In World War II American troops were warned never to eat fish that blew themselves up like balloons. It was during that war that attention was drawn to poisonous food from the sea.

Much research is now done in the extraction and identification of poisons from fish, which may be dangerous to eat throughout the year or only at certain seasons. The poisons from organisms upon which shellfish may feed on is also special research. An outbreak of paralytic shellfish poisoning was recorded in 1793, but in 1927 near San Francisco resulted in long term investigations.

These showed ten years later, that the unicellular flagellate *Goniaulax* was the causative organism. The excessive blooming of this flagellate may give rise at times in the sea to "red tides," whose resulting depletion of oxygen produces mass mortality of fish.

The jellyfish *Chironex* which lives in waters along the Queensland coast of Australia has caused many deaths. It is the most venomous animal at present known. Thus, its danger is compared to with that of a shark.



Many marine animals are remarkable in having some organ or tissue which is suitable for physiological study. For instance, the first direct evidence that insulin comes from the islet tissue of the pancreas of the angler fish.

A common jellyfish has the habit of luminescing. The luminescent reaction is triggered by the presence of calcium, even in molecular quantities. This substance has been extracted and is named Aequorin, which is in use for the research on the squid axon, for it immediately lights up on the passage of calcium through the axon membrane.

The puffer fish produce a poison which blocks the membranes of nerve and muscle fibers so that they are not permeable to sodium ions. It is 100,000 times more active than local anaesthetics such as procaine and cocaine and has been used as an analgesic.

The sand dollar has been used for studying anti-cancer drugs; and the spiny dogfish for investigating the transport of compounds across the blood-brain barrier. The sea urchin has spines that may possibly be used as templates for making artificial blood vessels for coronary surgery. These and more marine animals may have a great value to us in the future.

Another medicinal value is from that of the polychaete worm. In Japan, they were used as bait and the fisherman noticed that when flies and ants settled on it, they died. The killer was nereistoxin which was found to have a ganglionic blockage action that led to the production of a new insecticide. It has been marketed as "Padan," and has been used in the control of the larvae of rice stem borers and other insects.

The ocean was considered to be so vast that it could afford to have wastes poured into it without much harm, but oil accidents have destroyed much in terms of animal and shore life which in turn affects the foodweb.

Careful monitoring has to be planned so that substances drained into the sea



won't cause so much harm or can be biodegradable.

Recently the ecology of the sea has been disturbed. Much tourism has affected the populations of marine animals and so on, by the disturbance of their habitat.

Man should deliberately alter the environment so it will be able to equalize, and the foodweb can proceed as naturally as possible. It is for this reason that it is necessary to know the fauna and flora of different regions to gain a full understanding of their ecology before some major undertaking can be started.

The seas has many values for physiological research and will play an increasing part in the development of medical science. They cover three quarters of the earth's surface and provide infinitely more space than that of land. There is no doubt that in the years to follow, many new fascinating discoveries will be made.

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REEF BUILDING CORALS  
by Ramona Carreira, St. Joseph High School

Coral, a limestone formation is formed in the sea by a million tiny animals. Coral formations may look like branching trees, large domes, small irregular crusts or even like tiny organ pipes. The living coral-forming animals color the formation in beautiful shades of tan, orange, yellow, purple, and green. When the animals die they leave limestone "skeletons" that form the foundation of barreirs and ridges in the sea called coral reefs.

Coral reefs look like lovely sea gardens, because of the many colorful sea animals that live among the corals. Sometimes coral masses build up untill they rise above the water to form coral islands.<sup>1</sup> The grinding battering sea helps to build coral islands. It breaks up the coral and piles them up. Often soil lodges on the coral and vegetation begins to grow. Many Pacific islands were formed this way.

A reef is a biological community on the sea floor that forms a solid limestone (calcium carbonate) structure strong enough to withstand the force of the waves.<sup>2</sup> The predominant organisms in most of these communities are the coral and algae. The algae tends to grow over the coral, encrusting it, giving it strength, and forming a solid structure. Since most reefs grow at above sea level, they must be strong enough to withstand the eroding powe of breaking waves.

Corals of the reef-building type have very special requirements for growth. They need water temperatures above 70°F., and perish in places where the winter temperatures drop below 65°F. These temperature immediately eliminate all but the tropical and subtropical seas. Most of them live in shallow water less then 150 feet deep. It eliminates most of the oceans, except where special underwater conditions



produce platforms for their growth. Fresh water kills them, so coral reefs will not grow where rivers reach the sea, or where the rainfall is usually high. On the other hand, they cannot grow where the water is too salty; as much as a 4.8% level of salt in the sea is fatal. They must have fairly clear water, low in smothering silts and sediments.<sup>3</sup>

Coral reefs are formed by tiny animals called polyps. They are related to the hydras, jellyfish, and sea anemones. Coral animals range in size from less than an inch to more than a foot in diameter. A coral polyp has a cylinder shaped body. At one end is a mouth surrounded by tiny tentacles. The other end attaches to some hard surface on the bottom of the sea.

Most coral polyps live in colonies. Coral polyps reproduce either from eggs or by budding. Small knob-like growths called buds appear on the body of an adult polyp, or on the connecting sheet, from time to time. These buds grow larger, separate from the parents and begin to deposit their own limestone in the colony. Budding helps the colonies increase their size. New colonies form when the adult polyps of an old colony produce eggs. The eggs grow into tiny forms that swim away. Then the developing animals settle to the sea bottom and begin to form new colonies of budding.<sup>4</sup>

As the reef grows, it normally takes on a cup-shaped appearance underwater. The corals on the outside, exposed to the deep, oxygen-rich water of the open sea, grows faster than ones in the center of the reef, where the water is quiet.<sup>5</sup>

Three reasons for island formations are the accumulation of dead coral on top of a reef through wind and wave actions, drop in the level of the sea around a reef, and the upraising of the ocean floor beneath a reef.<sup>6</sup> Two or even three of these processes may have taken place on the same reef. The result is the gradual creation of an island. Millions of people live on islands that are entirely built of coral. Bermuda, the Florida Keys, some of the West Indian Islands and hundreds of the Pacific Isles were brought into being by the toiling polyps.



Hawaii is near the northern boundary of the coral growing region, and abundant. In the tropical Pacific, coral reefs form circles of low flat islands around shallow lagoons. Hawaiian Islands are the top of volcanoes rising above the surface of the ocean. Each volcanic island has become encircled by coral.<sup>7</sup>

The process that starts the coral reef is the fringing reef. It's the most common and widespread, from along rocky shores or around islands. The coral begins to grow just below the low tide mark and extends outside as a shallow platform. The width of the fringing reef depends upon how steeply the underwater shore slopes. A shallow slope helps to make a wide reef. A steep slope makes a narrow one.<sup>8</sup>

The different colors show the different colors of the coral. The fringing reef is red in color.<sup>9</sup>

The rim is the highest part of the reef, generally awash at mean low tide, and exposed above the spring tides from several inches to a foot or more in certain spots. The reef flat is the portion between the rim and the shore. At high tide the waves break just outside the rim and crash upon it with their utmost power. At low tide they break a little farther out, but each wave sends a foaming water over the rim, and as the waves recede this sheet of water drains both ways, part of it flowing down the gentle slope toward the shore and part flowing down the steeper outer slope, only to be met by the next wave.

Practically all the reef rim whether of the continuous ridge type or of separate protuberant heads, has associated with it one or more species of the coralline algae. Two structural types are found in the breaker zone, a crustaceous form which is the more abundant form with short stout, compactly crowded branches.<sup>10</sup>

The Barrier reef, a second type, is separated from the mainland by a passage or channel.<sup>11</sup> The reef may be mainly underwater, as in parts of the West Indies, or it may include chains of islands, as in the Great Barrier reef of Australia.



The Barrier reef is a pale blue color.<sup>12</sup> The reef is separated from the landmass by a lagoon. The reef can be a very imposing structure.<sup>13</sup>

The Barrier reefs follow the shoreline but are separated from it by water near the shore and the open sea. A barrier reef may consist of a long series of reefs separated by channels of open water. Such reefs usually surround volcanic islands of the South Pacific.

The best known of the coral reefs are atolls, or coral islands. These ring-or horseshoe-shaped reefs enclose lagoons, quiet, shallow areas of the sea.<sup>14</sup> The lagoon may be ten to twenty miles wide. None is over 180 feet deep and most are much less than that. Above the living reef are one or more islands where coral sand has piled high enough for trees to grow. People live on these low atolls, which are safe, except during typhoons or other severe storms.

The atoll reef is bright blue in color.<sup>15</sup>

The atoll reef is a ring shaped coral island in the open sea. It forms when coral builds up on a submerged mudbank or on the rim of a crater of a sunken volcano. The atoll surrounds a body of water called a lagoon. One or more channels connect the lagoon to the open sea. Many coral islands of the South Pacific are atolls.<sup>16</sup>

The atoll reef is an oval-shaped reef surrounding a lagoon not associated with an obvious landmass.<sup>17</sup>

There are two places within the United States where coral reefs can be seen.<sup>18</sup> The Hawaiian Islands are fringed with coral reefs and the reefs are extremely interesting, though small. One outstanding location is Coconut Island, in Kaneohe Bay, off the Island of Oahu.



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REEF BUILDING CORALS (BARRIER): CONSTRUCTION AND DESTRUCTION  
by Colleen Shikuma, Waiakea High School

INTRODUCTION:

"Coral reefs, as described by Darwin, were of three kinds: (1) Fringing reefs, round or along the coast of islands, (2) barrier reefs, and (3) Atolls which are more or less ring or horseshoe-shaped ridges of reefs with a lagoon in the centre."<sup>1</sup>

Coral reefs are found mostly in warm waters and tropical seas, because the reef forming corals cannot live in water colder than 65°F (18°C). Reefs abound throughout the South Pacific, in the eastern Indies and the Indian Ocean to Sri Lanka, and around Madagascar on the Southeastern African coast. They also form along the tropical eastern coast of Brazil, through the West Indies, along Florida coast, and at Bermuda.

Fringing reefs are submerged platforms of living coral animals that grow out from a land mass and always maintain contact with it. It's a flattened reef that varied in width and can be as much as 1/2 mile wide.

Barrier reefs are large and more or less narrow reefs that follow the shoreline, but are separated from it by a lagoon. They form between the water near the shore and the open sea to serve as protection for larger islands and even coast of continents by decreasing the force of water moving on shore. The largest of these types is the Great Barrier Reef which is over 1,400 miles long and averages about 100 miles wide that lies along the continental shore off the coast of Australia. Smaller ones are found in the Bahamas and around islands in the tropical western Atlantic and South Pacific.

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<sup>1</sup>Isobel Bennett, The Fringe of the Sea, (San Francisco, Trini-Ocean Books, 1976), p. 227.



Atolls are characteristically formed in midocean, far removed from any land masses. They are surrounded by deep water on all sides, but enclose a shallow lagoon. In some cases, the tops of these reefs protrude from the sea and have sparse vegetation.

#### Statement of Problem:

Today, to some extent, the barrier reefs are protected. However if nature, man, and modern technological development are not kept in balance and in check, the future of these reefs may be in danger.

Destruction by biological agencies is a continuous process - the boring algae, sponges, mollusks, worms, and echinoderms can cause weakness and eventual breakdown of the coral colonies, or at least portions of them.

Physical agencies such as wave action, especially during cyclonic storms and hurricanes which destroy their exterior, result in the upheaval of large blocks of coral which are hurled across the reef crest to the boulder zone behind it, and on down the seaward slope of the reef, smashing corals as they fall. Corals weakened by the boring organisms are broken off, and with other debris, are carried backward and forward across the reefs by racing tidal currents. By this abrasive action, these coral fragments are broken down into rubble and sand, abrading others in the process, but eventually filling in crevices or adding to the sand flats of the reefs.

It has been estimated that normal wave breaking against the windward side of the coral atoll dissipates half a million horsepower and the force of a storm wave is many times greater and yet these reefs continue to survive and flourish.

Heavy rains which reduce the salinity of water and currents which cover the corals with river mud are just some of the traditional threats made to coral.



"...the most notorious and immediate threat facing the reef is the infestation of the crown of thorns starfish, a voracious creature with such a taste of polyps that it is eating great stretches of the coral forming the Great Barrier Reef."<sup>2</sup>

The Crown of Thorns, (Acanthaster planci) is quite large for a starfish. It measures, on the average between 12 and 20 inches across. It also has an uniquely large number of arms: from 9 to 23 with 16 being most common in the waters of the Great Barrier Reef. Most starfish have only about five arms.

The upper surfaces of the animal are covered with wicked-looking spines from which it derives its name. These so-called spines range from 1½ to 3 inches and are sheltered in a kind of skin that produces a venom when it is broken. Its effects on humans varies from a mildly pleasant form of anaesthesia to vomiting and a sharp pain that can last for as long as 24 hours.

Along the under sides of the numerous arms of the Crown of Thorns there is an array of tube-like feet equipped with versatile suckers which are its means of locomotion and adhesive to the coral. These also act as sensory organs, enabling the starfish to react to light variations (it prefers the dark, moving from shadow to shadow). The color of the Crown of Thorns is adjusted to its habitat. It is generally well camouflaged against various colors that are found on the living reefs. The upper side of the body has mingled spots of gray, red, fawn, and green, while the arms are bluish gray and black and the tips of the spines are reddish orange.

Even more formidable than the animal's anatomy are its carnivorous feeding habits. It is one of the few creatures that devours coral polyps with notice-

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<sup>2</sup>Craig McGregor, The Great Barrier Reef, Amsterdam. Time Life Books, 1974. pg. 156.



able effects. Its method of eating is as simple and efficient as that of other starfish. It crawls onto a piece of coral, everts its stomach through its mouth and brings the stomach lining into direct contact with the coral surface. Then it digests the polyps and other tissues and moves on, leaving a whitened dead coral skeleton.

Among the dangers facing the reef is tourism. Every year thousands of people visit the more accessible islands and cays. People like holiday makers, fishermen, skin divers, boat owners, water skiers, and just plain sightseers come visit these islands. Most of these people are Australians although some come from overseas. Hotels for tourists, underwater observatories, and commercial aquaria are built for the tourists' pleasure.

As more and more people come every year, the pressure on the reef increases. Shell collecting, for instance, is a hobby all over the world, and the reef is full of many varieties of shells. Tourists look around for shells, and usually end up taking home rare shells as souvenirs. Even though there are laws that ban shell collecting within certain specific limits, a number of illegal shells still reach the souvenir markets. Spearfishing is also a threat. Though it is banned in some waters, it is still permitted elsewhere and too many Great Barrier Reef fishes are easy targets for skin-divers.

Other hazards originate in the sea. Foremost among these is the issue of pollution of the sea water by oil and other substances carried in ships. Recent accidents have made the point that even the largest super tankers can easily be damaged, so it makes the risk of a very serious oil spill even greater due to the huge cargoes that are now being carried on these ships. The threat from oil pollution is bad enough, but the damage to marine organisms



resulting from the use of detergents that are applied to get rid of the oil are even greater. Oil itself, although harmful to some marine life, is not so toxic as by the means of booms. This process can only be done when the weather condition is right and where the necessary equipment is available. In cases near the coral reefs, it is virtually impossible to do this so it must be regarded as a high risk.

Apart from oil spills, there are other types of pollution in the sea. One example is the accumulation of pesticides, insecticides, and fertilizers. In many tropical areas, because of the vast amounts of area under cultivation, pesticides must be sprayed from the air. A popular pesticide among cane farmers is DDT, which is valued because of its low cost and its failure to decompose easily and disappear - the very quality that makes it a serious factor in off-shore pollution. Somehow, it finds its way to the seas either directly through rivers or indirectly by the way of the process of food distribution and waste disposal. DDT is absorbed by small fishes or gradually becoming incorporated into tissues of marine animals. From there they are passed on from one predator to another in increasingly powerful concentrations until some creatures higher up in the food chain, such as birds, weaken or fail to breed.

A more complex threat is posed by the development of industry, agriculture, mining, and other technological developments. Those coral reef areas which lie on or at the edge of the continental shelves may suffer from yet another source of risk. They are effectively situated over shallow bottoms which sometimes contain, as in the Great Barrier Reef, a wealth of minerals. These natural deposits lie within man's reach as a result of new techniques.

Mining, in which vast sums of money are at stake, take a lot of time and patience but in recent years, we have seen an extraordinary mineral boom in



Australia. Huge resources of iron ore, bauxite, oil, gas and other natural riches have been discovered. In 1960s, the Queensland government gave permits to oil companies to drill on the Reef. Two exploratory bores were sunk, one on Wreak Island and the other on the far northeastern part of the reef. Both were unsuccessful but the companies did not give up and by 1970, they had permits for about 80% of the Reef which is approximately 80,000 square miles. It was not until 1970, when an oil rig was about to start drilling in Repulse Bay, a few miles from the tourist resorts of Whitsunday Passage. Suddenly, the Australians were alerted, and they started a campaign to save the Barrier Reef. A major battle broke out, conservationists versus the oil companies, the Australian Commonwealth (or central) government versus the Queensland state government, and the public right versus the private interest.

The Repulse Bay drilling was postponed and a Royal Commission was set up to inquire about the oil exploration on the Barrier Reef and its possible dangers. In 1972, the Labour Party came to power, having pledged itself to take over all offshore waters and oil rights, and to protect the Great Barrier Reef.<sup>3</sup>

The reef escaped the threat of oil exploitation, but its other minerals are a lure for industrialists and developers. Limestone, of which the reef consists, could be used as agricultural fertilizer or in the production of cement. The first attempt to mine the reef was in the late 1960s by sugar farmers of the Caines district. Their application was turned down after some marine experts said that it would damage the Reef if it were to be mined for limestone. But it didn't mean that they would just do away with the idea but to look at it again in the future.<sup>4</sup>

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<sup>3</sup>Craig McGregor, The Great Barrier Reef, Amsterdam, Time Life Books, 1974. p. 164.

<sup>4</sup>Craig McGregor and the editors of Time Life Books, The Great Barrier Reef, Amsterdam, Time Life Books, 1974, p. 165.



### CONCLUSION:

In brief, if man does not enact laws and change his ideas and attitudes regarding the protection and conservation of the barrier reefs and their environment, it will mark the end of one of the great beauties of creation, and the end of great hope for these delicate creatures.

"Above all, however, it is human attitudes, rather than human laws, that we must try to change. We must modify our ideas on the sea. By wealth, it appears to us to be inexhaustible. But we have now discovered that, far from being proof against any and all depredations, the sea is surprisingly limited, and astoundingly fragile."<sup>5</sup>

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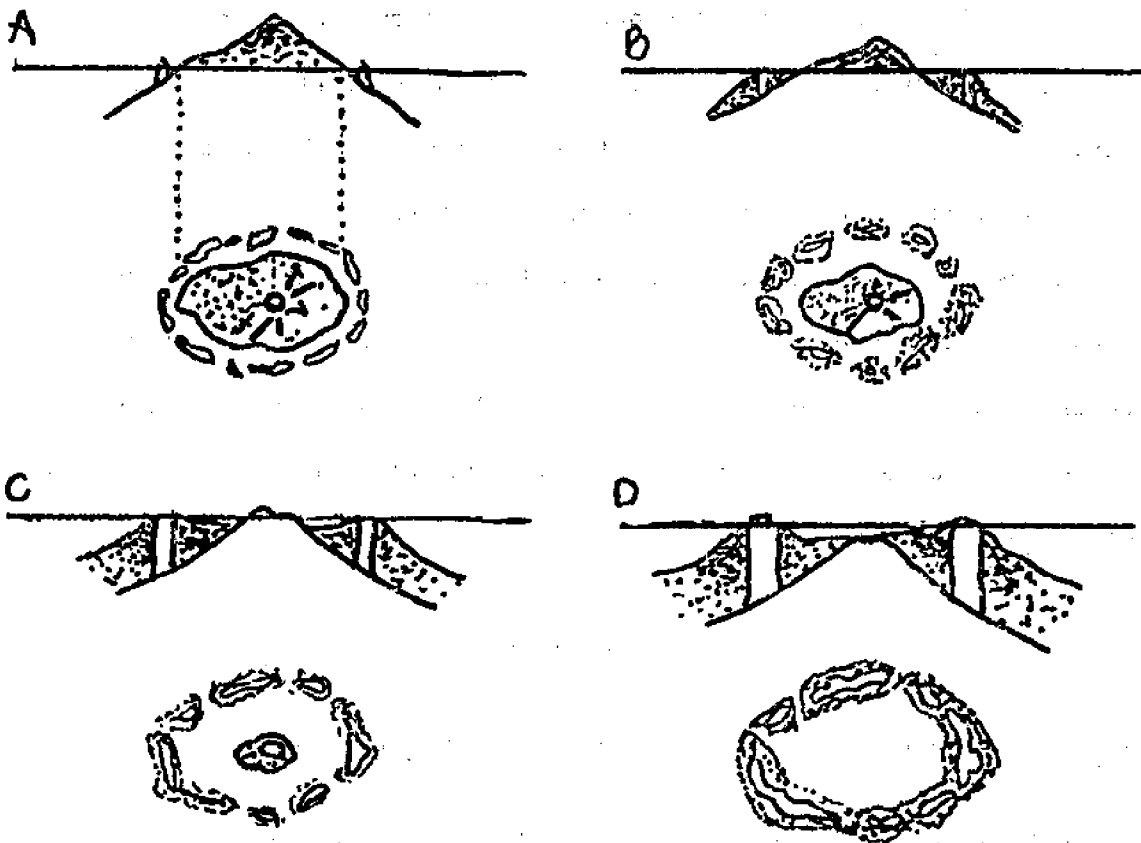
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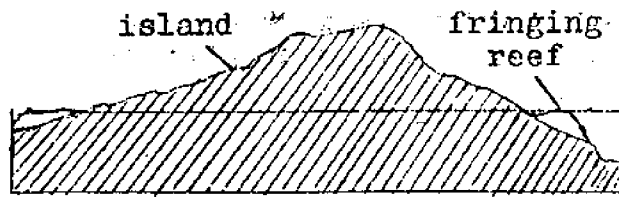


#### Formation of an atoll, after Darwin.

- |   |  |
|---|--|
| <p>A. Volcanic island with small fringing reefs beginning to form.</p>                | <p>B. As the volcanic island sinks, the reefs keep pace and remain at the surface.</p> |
| <p>C. As the process continues, sedimentation builds up the bed around the reefs.</p> | <p>D. Final formation of an atoll with a lagoon.</p>                                   |

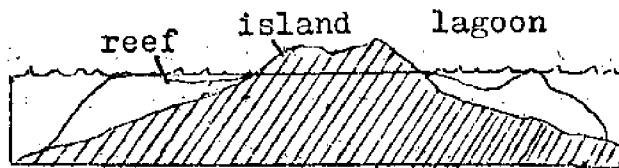


Fringing  
reef



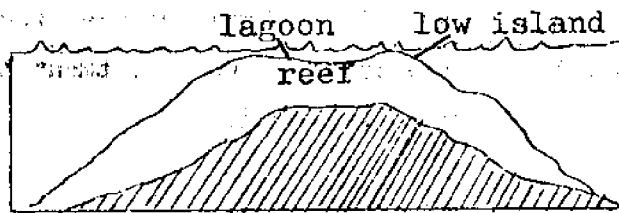
Sea level

Barrier  
reef



Sea level

Atoll



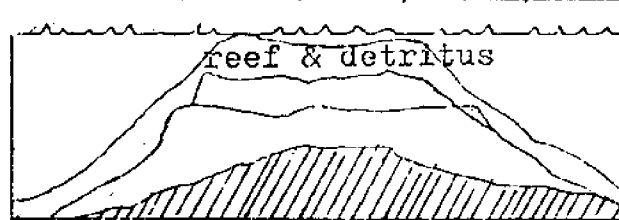
Sea level

Atoll



Sea level

Atoll



Sea level

The development of coral reefs according to Darwin.



**DANGEROUS MARINE ORGANISMS OF HAWAII**  
by Darla Hee, Sacred Hearts Academy

**Abstract**

All through Hawaiian waters there is an abundance of marine life. There are a few which can be extremely dangerous, and there are even fewer which are harmful enough to bring death to man. My report includes those which are deadly and those which are not but are harmful. I have included their descriptions, the injuries and symptoms which they may inflict, the treatment that can be used, and the preventative measures that can be followed.



## DANGEROUS MARINE ORGANISMS OF HAWAII

All through the waters of the Hawaiian Islands there is an abundance of fascinating marine life. Most of Hawaii's beautiful beaches are quite safe, but there are always some dangerous sides to them. In my report I will be telling you about some of the dangerous marine organisms, their description, the symptoms or injuries that they may inflict, the treatment that can be used, and the preventive measures that can be followed. I'm writing my report on this particular topic to help prevent unnecessary injuries and to make the people aware of what treatments they should use in their situation.

### PORTUGUESE MAN-OF-WAR

The Portuguese man-of-war are members of the phylum Coelenterata. The biological name is Physalia physalis, and the Hawaiian name is Pa' malau. The man-of-war is bluish in color. It is a transparent collection of countless small animals banded together to form what looks like one organism. The gas-filled float may be as wide as 5 cm with many short tentacles and one long tentacle attached to its body. These tentacles can grow to about 2 m long. Each tentacle is equipped with microscopic stinging cells, which are scattered along the length. The harmful toxins are released by these tentacles. They are often found in large numbers drifting on the surface of the water. The man-of-war can be found on the open ocean seasonably and is carried to beaches by the waves. Here in Hawaii, they are found most on the windward shores, when there are tradewinds or strong onshore winds.

A sting from a Portuguese man-of-war can produce reactions ranging from as much as severe discomfort to as little as stinging and prickling feelings. There are some people who may have an extreme allergic reaction to the sting. This may include an attack somewhat like an asthma attack.

For treatment of the Portuguese man-of-war sting there are several procedures which can be followed. One form of treatment is the application of a paste



of unseasoned meat tenderizer mixed with alcohol on the affected area. Then leave the paste there for about 10 to 20 minutes. After you have waited the allotted time, rinse off with alcohol. Papaya is an ingredient present in the meat tenderizer, so if the victim is allergic to papaya, do not use this method. Another method that can be used is by applying nonirritating powder, isopropyl alcohol, urine, or hard liquor. Then apply a saturated solution of baking soda or a diluted solution of ammonia. One popular method that should not be used is rubbing sand on the affected area. Doing this will only increase the irritation. The tentacles should be carefully taken out of the skin. The method that the Hawaiians used was to apply green papaya or urine directly on the area stung.

To prevent a sting, try to stay away from them as much as possible and never touch them. Do not touch them even after they have died, for the toxin remains in the tentacles several hours after death.

#### SEA ANEMONES

Sea anemones are coelenterates of the order Madreporaria. Their biological name is Adamsia palliata, and its Hawaiian names are Okōle-emieni and Okole-Hāwale. A few of these small species can be found attached to rocks or sand at most depths of the ocean. Most are found at or below the low-water level. The sea anemones can be as small as 1 mm or as large as 15 cm. Many varieties are very colorful and look like a flower growing on the top of a thick stalk. The anemone's tentacles contain the stinging cells, and these stinging cells contain microscopic barbed spines.

A sting from some sea anemones can produce burning and localized itching, which may vary from as little as a prickly sensation to as bad as extreme pain. Some allergic reactions which may result are headaches, nausea, vomiting, and fever.

The same treatment for the man-of-war should be used for an anemone sting.



To prevent getting stung by a sea anemone, look where you place your hands, and wear gloves to protect them.

### SPONGES

The sponges belong to the phylum Porifera . Their Hawaiian names are hu'ahu'a-kai and hu'a-kai. Many species of the sponge are harmless and are of great commercial value. Sponges play an important part of most bottom environments, and can be found on most shorelines. They are found up to depths of 10,000 m and come in a large variety of sizes, colors, and shapes. The small spicules of glass or lime or spongin fibers, either combined with spicules or alone, are the body support for the soft structure.

When the sponges are handled, their spicules get embedded under the victim's skin. The first symptoms start with painful itching, which is something like contact with poison ivy. Several hours may pass before the fingers and sometimes the whole hand begin to swell and become nearly immovable. More pain will be produced if you try to flex your fingers. The effects, especially the aching, may stay for as long as one to two days, after which the swelling leaves and moving the fingers will no longer be painful to do.

For treatment of the sting use the same methods as for the Portuguese man-of-war. Diluted acetic acid has also been found to help reduce the effects.

Use gloves when handling the sponges to prevent an injury.

### JELLYFISH

The jellyfish is really not a fish as its name says, so they are more properly known as jellies. All jellies are members of the phylum Coelenterata and are among the most primitive organisms. Their Hawaiian name is Pololia. The jellyfish are self-propelling organisms. Their movement is achieved by the rhythmical pulsing movement of the whole body. The size of the jellyfish may range from as large as 30 cm to as small as 11 mm in diameter. The jellyfish can be found in the open ocean or in calm bays, but



if they are caught in strong tides or driven shoreward by wave action, they are automatically in trouble. The open ocean types are often swept to the shore by storms. Because they are transparent, the jellyfish are often difficult to see. All types are over 98% water even though they seem firm enough to handle. Some jellyfish produce a mild stinging rash, while fewer are rated as capable of giving a painful injury, while even fewer are considered to be highly dangerous, but at least one type has been called the dangerous creature of the sea. The Cassiopea or "upside-down jellyfish" lies on its belly on sandy bottoms. It is commonly seen in areas like Kaneohe Bay and the Hilton Hawaiian Village lagoon. When it is disturbed, small pieces from the tentacles break off causing stings.

A sting from a jellyfish will produce a stinging and prickling sensation. It may also produce blisters. There have been people who have gotten an allergic reaction. They may have difficulty and irregularity in breathing and cardiac irregularities. If these symptoms are present, seek emergency help immediately.

When a sting does occur, you can use the same methods as for treating a Portuguese man-of-war sting. The old Hawaiian remedies include putting a direct application of green papaya or urine on the sting.

To prevent a sting, avoid contact or handling of a jellyfish.

#### HYDROZOA

The hydrozoa is often mistaken for limu. Hydrozoa are colonial organisms which are found on artificial habitats, like bottoms of submerged lines, pilings and floats. Or they can be found in places that are rich in nutrients like Kaneohe Bay. The shallow water hydrozoa, which range in size from 1 mm to 15 cm, have about 30 different species. Many of the colonies have a thick main stem and a lot of branches that look like a fan or like a tree branch with little fuzzy anemones on the ends and sides of every branch. The colonies of hydrozoa



have microscopic stinging cells like those of the Portuguese man-of-war and the jellyfish. The sting causes itching and burning and a rash that may last as long as several days or as little as several hours. Some people may get a severe allergic reaction from the sting. Swimmers will usually get a rash on their legs, abdomen, and chest when stung.

To treat a hydrozoa sting, use the same method as used for the Portuguese man-of-war.

To prevent stings, try not to brush against places where they may be found, like on the undersides of floats.

### CORAL

The Hawaiian name for coral is Ko'a. Coral can be found in many forms. It is one of the most important of the colonial animals, because various types are responsible for the building of the reefs and some go on to be the base of an island. Coral grows in depths up to about 80 m. Many polyps with razor-sharp edges and slime cover the common stony coral. You can find the coral in an array of colors ranging from shades of pastel pinks and yellows to white and brown. Fragments of coral can be embedded in a cut, making it slow to heal and prone to bacterial infection. Coral does not grow in the cut, as said by many sources. Stinging cells, which can cause irritation, are found in all corals.

Infections can result from a cut, even though the cut seems clean. Tenderness and inflammation may often be produced by tiny fragments of coral lodged in the cut. This will lead to a festering sore and a spreading infection.

To clean a cut, use hydrogen peroxide to remove the coral pieces. Then apply an antiseptic as soon as possible. Be sure to update an anti-tetanus immunization if needed. For treatment of irritation use the same methods as is used for the Portuguese man-of-war.

For prevention of cuts, when you are walking or wading on the reef,



wear sneakers or tabs. When handling the coral, wear gloves and use fins with a full heel for protection when skin diving.

### OCTOPI

The Hawaiian name for the octopi is He'e. Locally, the true octopus are often called "squid". The octopus has a rounded sac-like body, with eight tentacles attached to it. The timid creature hides on the sandy bottom or in holes. Its beak is capable of inflicting a wound, and is located in the center of the underside of the body. The day "squid" and the night "squid" are common species in Hawaii.

A bite from an octopus can produce a skin wound, with possible bleeding. When bitten, the toxin from the salivary glands maybe injected into the victim. The toxin may cause discomforting irritation that is similar to that of a bee sting.

For treatment of a bite use the same methods that are used for the coral. Be sure to update the anti-tetanus immunization if necessary.

If you are handling an octopus, be careful of its beak to prevent from getting bitten.

### CONE SHELLS

The Hawaiian name for the cone shell is pupu. There are at least 400 different species of the cone. They can be found in the tropical seas of the world. They are conical in shape and usually have black or brown patterns on the shell. In size, they range from 1 to 10 cm, and can be found in crevices or buried in the sand on the undersides of boulders and dead coral. Some of the species have a deadly poisonous dart that can kill those handling the shell. Most dangerous cones are found in the Indo-Pacific. The apparatus from which the venom comes is in the form of a dart, which is tucked inside the shell's cavity. This is connected to a ligament gland attached to a venom gland or duct inside the shell. Some are deadly to man.



Minimal to severe pain may be felt from a puncture. The effect of the poison can either be numbness with inflammation, or local stinging, to possibly paralysis, or death. These occur very rarely. After the injury, vomiting may occur and last from 2 to 4 days.

To treat injury, soak affected area in very hot water, but not scalding water, for 15 to 90 minutes. The victim should be treated at the nearest emergency medical facility because the toxin can be highly dangerous. If necessary, update your anti-tetanus immunization.

To prevent being stung, observe great caution when collecting live specimens. When picking them up, pick them up very carefully at the blunt end and carry in a plastic bag filled with water.

#### SEA URCHINS

Sea urchins are echinoderms, which are closely related to sea cucumbers, starfish, and sea lilies. Some of these look very much like plant life, but they are marine animals with limy plates that serve as skeletons. Some sea urchins and some species of the Pacific starfish can be considered dangerous, of all echinoderms. There are two types of sea urchins, that are commonly encountered and potentially dangerous. The first, often called wana, has long, brittle, needle-sharp spines. The color of the wana is violet-black or black, with bands of white on the spines. The wana can grow up to 25 cm in diameter, and can be found at most depths either in the open or in crevices. Ina is the second type, which is oval-shaped and has shorter, thickened spines. They are usually pinkish, black, or greyish-green in color, and live in the holes along the shoreline. There are a few species of sea urchins that can inflict painful puncture wounds, while there are fewer that are poisonous. The dangerous ones are found in tropical waters and the venomous spines have poisonous fluid that may cause painful irritation and have even caused death. The black sea urchin, found in Hawaii, is one of the most dangerous.



Immediate throbbing pain comes from the spines of the wana, which usually break off and remain lodged in the flesh. This pain may last for hours. If the spines are not removed, an infection can develop. The puncture wounds are characteristically blue-black in color. The 'ina can also cause wounds if contacted directly, but since the spines are strong, they usually do not break off.

For treatment of wounds, use the hot water treatment used for cone shells. Other remedies include putting a direct application of undiluted vinegar or the application of urine. For long embedded spines, see a physician. An anti-tetanus immunization may be needed for puncture wounds of long spines. To keep from infection, keep all wounds clean.

To prevent any wounds, wear tabis with thick soles, and gloves, when diving or walking on the reef. Try to avoid touching the reef or putting hands in the crevices without looking. If you do not know sea urchins, do not handle them.

#### LYNGBYA MAJURCULAE

The lyngbya majurcula is more commonly known as limu, here in Hawaii. They are commonly found intertwined with other seaweeds in reef or coral flats, in tidepools, or in deeper subtidal environments. The limu can be carried in great amounts by waves to swimming area like Kailua and Laie, and other windward areas. The limu often forms floating masses on the surface of Kaneohe Bay, which are one or a few hundred grams. This fine algae is blue-green and can also be found black-green in color.

Lyngbya majurcula can cause minimal to severe inflammation of the skin, when fragments lodge in swimmers swimsuits, especially if the victim is allergic to the algae.

Wash the exposed area immediately with soap and water then change swimsuits, when contact has been made with limu.



Those who are allergic to the algae should keep out of the water when there is an abundance of the algae to prevent any irritation.

Through research for this paper, I have learned a lot, and I hope that those who have read my report would have also learned something from it. In my effort to write this paper, I hope it can be of value to someone else in the future.

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# **Aquaculture**







**AQUACULTURE**  
by Mark Kennett, St. Joseph High School

With the shortage of food these days aquaculture is being expanded radically. With its roots in Southeast Asia aquaculture is growing all over the world with extensive Mariculture Conferences and meetings taking place each year. I've chosen to take a more in-depth look at the rearing of the Malaysian prawn or *Macrobrachium rosenbergii*. I've chosen this because I feel it is more appropriate to our Hawaiian environment and because it is in Hawaii that most major breakthroughs on the subject have taken place.

Most Asian countries have their own native stock of *Macrobrachium rosenbergii*. With Hawaii's geographical location the importation of shrimp from Malaysia was needed, and because of the many Asian people in Hawaii, the Malaysian prawn was thought of as a delicacy.

Hawaii is an ideal location for the rearing of the Malaysian prawn. The Malaysian prawn, a fresh water crustacean, can survive easily in Hawaii due to the amount of rainfall, Kauai being more advantageous because of its topography, and annual rainfall. Hawaii (island) also has an advantage because of its rainfall, but like most of the other islands, it is upset with a very uneven topography, Maui has the topography but not the rainfall, and Oahu also has the topography, but due to the urban development much of this land cannot be used.

There are many problems faced during the rearing of the shrimp. Some of these are temperature, water levels, sufficient supplies of unpolluted water, maintenance of favorable water conditions, food, and feeding, and a big problem is the prawns themselves - they are cannibalistic.



According to information received from Joe Serrao, of Kilauea Agronomics on Kauai, the biggest problem faced in Hawaii is maintaining the proper levels of temperature and oxygen. The average production of shrimp in order for a profit to be obtained is in the range of 30 to 40 kg. of shrimp per year.

Kilauea Agronomics, the biggest shrimp farm in the world, is looking into all these problems, and has more staff and scientists than almost any other aquaculture division. Funding for such a big operation is also a very important factor although Kilauea Agronomics is corporation-backed, and it is also a federally funded operation. Though most of the Hawaiian-reared shrimps are sold mostly in Hawaii, a recent dealership with a Japanese retailer has just been formed and a lot of shrimps now are sold in Japan.

Rearing the Malaysian prawn is not an easy task, in order for a profit to be obtained either by the private company or an individual. Many things must be considered before steps to operate a pond can be taken.

The depth and location, whether it will be man-made or natural, the temperature, the source of water, which must be constant.

The Kauai production ponds are all man-made, feeding of the shrimp is done by man with the use of pond pellets (#1) made by Waldron of Honolulu. The temperature of the water, which they like to be constant, is at the mercy of mother nature. However oxygen concentration can be controlled, by using different types of algae and with a huge oxygen aerator pump which works similarly to that which is used in a fish tank. Wind is also another factor in regulating oxygen concentration.



Reproduction control of the *Macrobrachium rosenbergii*, is another problem, mainly due to the shrimps themselves. This was shown in studies made by Shae-Won Ling, who put one nice looking female prawn and one handsome male prawn in a well aerated aquarium. When observing the tank the next day, the male seemed happy but part of the females head and body were missing, eaten by the male; in other experiments sometimes the entire female disappears. But a breakthrough came when the observation was made of a molted female change place. With the female's body soft, it was expected that the male was sure to eat her, but instead of attacking her, the male proceeded to lock the female in a protective embrace, and when her new shell formed they mated. It became evident that the mature male prawn is ready to mate anytime, but the mature female requires a premating molt. Before the premating mold, a mature female prawn is not responsive to the courting of the male. The male is apparently unaware of this and when he fails to get recognition from the female, he is frustrated and humiliated, and becomes angry enough to attack her. It was also found that when a female prawn molts it releases certain chemicals that attract the male. The male quickly forms a protective embrace around her, before other competitive females might attack her. After discovering the simple facts of life of the prawns, we could spawn them under controlled conditions either by individual pairs or in large groups. Another important fact in the pairing of the *Macrobrachium rosenbergii* is that after the first 5 days of life the prawn needs to be in an area that has quite a higher salinity level than other parts of the rivers or area in which it had been bred.

The raising of the *Macrobrachium rosenbergii* can be quite profitable because of their growth rate. They can usually reach a marketable size within the 3rd to 4th month after being hatched. Partial harvesting with some



nets is done at monthly intervals to remove large ones for the market and leave the small ones to continue growing. At the end of a harvesting cycle complete harvest is done, but unlike the ponds of Asia the ponds at Kilauea Agronomics do not have to be emptied and readied for the next stocking quite as much and there is much more of a financial profit in it. Because of this the potential for shrimp rearing in Hawaii is very promising, and with the food prices escalating more and more each year, the need for cheaper and better food sources growing, Hawaii has become the pioneer.

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AQUACULTURE: A POSSIBLE INDUSTRY FOR HAWAII  
by Gregory Lee, Kalani High School

ABSTRACT

Hawaii is considered the leader in production and the technological center of Malaysian prawn (*Macrobrachium rosenbergi*) aquaculture. Hawaii's ideal environment for aquaculture and help from a state agency puts Hawaii at the top in culturing the Malaysian prawn (Freshwater Prawn). Since Hawaii has many limitations on the raising of aquatic species, many solutions will have to be found before Hawaii can become an aquaculture center.



## INTRODUCTION

Aquaculture was used extensively in ancient Hawaii. Most of the ponds gradually disappeared over 800 years. The ancient Hawaiians were skilled at raising aquatic animals and plants. It would be nice to see the people of Hawaii once again raise aquatic species for consumption. I would like to see if it is possible for Hawaii to engage in and be a leader in aquaculture.

Aquaculture is a new and rapidly developing industry in Hawaii, as well as throughout the world. The definition of aquaculture is: The propagation and cultivation of aquatic animals and plant species for profit or social benefit.

There are many steps in aquaculture such as: research, development education, training, culturing (husbandry), production (growout), processing, market distribution, support goods and service, and technology transfer. All those steps are used in all types of aquaculture.

## MANAGEMENT SYSTEMS

Management system types are Release and Recapture, Pond Culture, Cage or Basket Culture, Raceway Culture, and Closed High-Density Culture. One or a combination of management systems may be used to raise aquatic animals or plant species. Release and Recapture (Natural Stocking or Ranching) is when young are placed in their natural habitat and recaptured when they are fully grown. The young are subject to natural fluctuations and predators. Pond culture is where animals are confined in earthen, concrete or other structured ponds. This is most widely used in



Hawaii. Stock nutrition and pond water quality may be controlled to some extent.

Cage or Basket Culture uses wire mesh or net cages to confine the animals. The cages are supported or suspended in flowing or static bodies of water. The cages can be placed in controllable water, a natural bay, or an open ocean platform.

Raceway Culture is a costly system and is a high-stock density system. Water rushes through the cages at high speeds. There is greater control over water quality, nutrition, and physical environment than other systems.

Closed High-Density is technologically intensive and costly. Control must be exercised extensively to ensure survival. The stock is left in a recycled flow of water.

#### DEVELOPMENT

There are many stages involved in the development of aquaculture. A species must first be selected and studied. There are many factors in the selection of a species. It can be bred in captivity and will grow acceptably in Hawaii's environment. The species must be able to be cultured in Hawaii's facilities and with manpower that is present. The feed for the species must be ready and available. It should be able to be raised in a large-scale operation and be economically feasible (e.g. no legal barriers and a present and/or nearby market). Finally any problems in the selection of a species should be well defined for future solution.

After these selection steps, the subject is ready for proto-



type testing. Prototype testing involves preliminary engineering, technological development and cost analysis economics.

If all goes well with the prototype, then a pilot plant is established. The plant provides information for possible industry such as detailed economics of the construction, and operating costs, and economic improvement and show a complete demonstration.

If everything is worked out in the pilot plan, then possibly industry could start using extension and support from the pilot plant.

#### NEED FOR CULTURE

There are many reasons for aquaculture. There is an increase in the population relying on the world's limited resources. Environmentally clean industries are a must in this age of advanced technology. Employment opportunities are needed for Hawaii's unemployed. There is a worldwide fishery product shortage which is likely to worsen. Traditional U.S. fisheries are near the limit and imports of products are rising.

A need for marine shrimp is present since the United States agreed with Mexico to stop fishing for shrimp in her waters. "The Mexican waters provided fifty percent of the U.S. consumption of marine shrimp."<sup>1</sup> Hawaii could possibly in the near future help supply marine shrimps to fill up the 50 percent gap.

If aquaculture develops more in the world, there will be a need for more food for these cultured stock. For example, Hawaii

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<sup>1</sup>Dept. of Planning and Economic Development, Hawaii Aquaculture Planning Program-Interim Report, Hawaii, 1977, p. 8.



is in a position to grow Larvae Brine Shrimp as food for prawns, marine shrimp, mullet, and other cultured species. "A mainland company's orders for the production of brine shrimp totaled \$567,000 and it had back orders of \$2,250,000."<sup>2</sup> This is an example of the market for brine shrimp in fresh and frozen form and this was in 1970.

#### ADVANTAGE OF INVESTMENT

There are many advantages of investing in aquaculture here in Hawaii. There are three main advantages of a new industry: jobs, more economy in the state, and a food source. Aquaculture can produce information that affects other areas. In brief they are: Research and Development, Land and Water Use, Economic Development, Development of Stocks of Sports Fish, Bait Fish, and Ornamental Fish, Sewage Treatment and Multi-Culture Systems, and Energy Systems.

Jobs will be provided in two sectors: Commercial Production (CP) and Research, Training, and Technological Transfer (RT&TT). There are three types of Commercial Production: the part-time family run operation, the small scale operation with hired employees, and the large scale operation associated with or owned by a large local, national, or international company.

RT&TT provides jobs for only a small sector of Hawaii's people. However indications are good for expansion. By 1985, 300-400 people could be employed in RT&TT using three federal

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<sup>2</sup>Ibid. p. 8.



government grants. The three grants are: 1975-Title XII of the Foreign Assistance Act, 1976-Section 406 of the Food for Peace, and the 1977-Comprehensive Farm Bill. A large part of these federal funds for RT&TT will be spent in Hawaii, thus boosting Hawaii's economy.

The dependence on tourism is too great in Hawaii, as the United Airlines strike has shown that Hawaii has lost millions of dollars.

The above projections for the commercial production and RT&TT sectors indicate that aquaculture can make a substantial contribution to Hawaii's economy. The state's economic base is presently limited. In 1976 only four sources (tourism, federal defense expenditures, sugarcane, and pineapple) accounted for 42 percent of the gross State reliance on imports, coupled with rising fuel and fertilizer costs, so that once productive agriculture areas have become uneconomical or marginal. Moreover, only non-polluting industries are able to satisfy the State, County, and Federal standards and permit requirements. State policy document have, therefore, stressed the need for new industries, such as aquaculture, which will diversify the economy, provide additional employment opportunities, and preserve the environment.<sup>3</sup>

With the world's dwindling supply of food, aquaculture could be the answer to our food needs. "Locally in 1976, 43,900 pounds of prawns were produced in 25.24 acres of land, that's about 1739 pounds per acre."<sup>4</sup>

#### LIMITATIONS

Aquaculture in Hawaii has many limitations and needs. There are three main types of limitations: social and economic, aquatic

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<sup>3</sup> DPED p. 5

<sup>4</sup> Bruce Benson, "Aquaculture: Land Impact", Honolulu Advertiser, June 1, 1977, A3.



environment, and biological.

The social and economic limitations are numerous and may take time to solve. There is a lack of government support and coordination. The location of land for aquaculture will probably be on agricultural land. The use of coastal zones and ocean waters are restricted by competition with recreation and tourism: The aquaculturist has no control of leased marine areas which result in poaching of crops, interference with equipment and crops, and trespassing on property. The fluctuations of the economy affect feed costs and market price. Commercial enterprises give a negative response or are hesitant to the idea of aquaculture. The investment (research and development) is a long term commitment which is expensive and the economic gain is unsure. Licenses must be obtained from many different governmental agencies.

The aquatic environment limitations are few. The availability and quality of water is a factor. Weather damage to crops and facilities is another factor.

The biological limitations deal with the environment and environmental factors. Diseases include bacteria, virus, or fungus infection. The cause of infections may be contaminated water. The water may be contaminated by too much feed, the larvae count is too dense, or the feed breaks up into too small pieces.

Infections can also be caused by poor soil quality, stress, and physical injury. Some of the factors that cause stress are



too much sunlight, poor water quality, inadequate diet, or high pH level.

Preventive medicine can reduce the amount of infections that will occur. Tanks and equipment should be cleaned and disinfected. The water used should be filtered. General care should be exercised to prevent contamination.

The availability of juveniles and the inventory of the species are biological limitations. The predation, competition, and nutrition of a species are other biological limitations.

#### POSSIBLE SOLUTIONS

More research and development is needed in many areas to make aquaculture more feasible. Basic research and applied development on a pilot project basis should have an effect on more commercial production.

A central agency is needed to establish procedures for licensing commercial identification and quality standards.

Not all ventures in aquaculture must be a burden upon the entrepreneur's sole savings. A company, The Aquaculture Insurance Service Ltd., a subsidiary of the Bain Dawes Group of England provides insurance. Their type of insurance provides much coverage:

We already provide mortality insurance, including necessary slaughter and loss from other causes, on many types of farmed marine species (also freshwater). We will consider all types of farmed marine species including valuable research stock.<sup>5</sup>

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<sup>5</sup> John S. Corbin, Aquaculture in Hawaii 1976, DPED, State of Hawaii, Honolulu, Hawaii, 1976, p. 30.



## GROWING OF FRESHWATER PRAWNS

An in-depth process of the culture of a species should be examined, since Hawaii is considered the manufacturing and technology leader in the world on Macrobrachium rosenbergi (Freshwater Prawns).

The first process of growing prawns is breeding. Healthy mature prawns breed year round. In Hawaii the females lay 15,000 to 30,000 eggs twice in five months. Males are placed in the tanks with females during this process to protect females that are moulting. The eggs are extruded six to 20 hours after moulting. The larvae are fully developed in 16 to 17 days in water six to 12 ‰ (parts per thousands) salt content. They hatch on the 19th or 20th day in a 24-hour period.

The larvae will go through 11 stages of changing, only eight are apparent and three need closer examination. They are planktonic, and are constant feeders in the larval stage. They now swim tail first, head down. Only on the 10th day do they swim in groups under the surface of the water. While they are in metamorphosis a screen must be placed over the tank to prevent them from jumping out. They eat with their maxilleped and thoracic legs. The egg sac remains with them in their larval stages of growth, usually two or three stages. The larvae will eat zooplankton or greenwater. Greenwater is produced from seawater and a municipal water mixture. The greenwater is ready after five days in 5,000 gallon tanks with around 50 adult tilapia to promote growth, and is placed in larvae rearing tanks. The



larvae will cling to objects in the water. More objects are added to the water to prevent cannibalism. The metamorphosis occurs in 30 to 45 days.

The juvenile prawns are only slightly bigger than the larvae. They are called juvenile prawns after 60 days as post-larvae. Juvenile prawns act just like adult prawns and their shell hardens most at two months. They are now placed in a grow-out facility or a pond. In one square meter there are between 12 to 18 juvenile prawns.

The food must meet many requirements since the adults eat two-thirds of the food. It must be stable in water for 24 hours and have no leaching of nutrients to provide good growth. It must cost as little as possible and be easily handled. The supply and cost must not vary significantly, while fitting with current manufacturing methods. It must be non-toxic and disease-free while having a long shelf life. The size of the food depends on the size of the prawns. In addition to greenwater, raw fish, catfish pellets, trout and shrimp pellets, chicken feed, Oregon moist pellets, and lipids from marine shrimp may also be used.

Prawns may be cultured in Monoculture (single crop) or Polyculture (a combination with other aquatic animals). Some experimenting with polyculture has been done, but monoculture is presently the most effective. Harvesting is done by draining the pond through a sieve catching all the prawns into a seine or pump. A second way is to trawl through the pond, and strain for the bigger prawns while leaving the smaller prawns behind using a



mesh net.

In Hawaii there is already a market for prawns. "Wholesale price is \$3.00 to \$3.50 per pound, retail price is \$4.50 to \$4.95 per pound. There are about six to ten prawns per pound."<sup>6</sup> In the packaging process they are flash killed in ice water then blanched in water at 150° for 15 seconds and then put on ice to last up to six days. The best selling market is four to six on a plate.

#### PRAWN SUCCESS

There is one main reason why Hawaii is considered the manufacturing and technology leader in the world of Freshwater Prawns. The reason is that the Anuenue Fisheries Research Center of the Department of Land and Natural Resources provides technological and biological assistance to aquaculturists in Hawaii. The center provides "free" juvenile prawns and advisory services to aquaculturists in exchange for data obtained while crops are raised. The advisory services are diagnostic and preventive treatment of prawns, formulation of efficient feed, mechanization of farming methods, development of processing and marketing methods and development of superior genetic strains of prawns. Future research is being done on present advisory services and a prototype of a semi- or full-automatic freshwater hatchery.

#### CONCLUSION

The problems of aquaculture in Hawaii are numerous and must

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<sup>6</sup>Harold Leland Goodwin, The Aquaculture of Freshwater Prawns (Macrobrachium Species), Waimanalo Oceanic Institute, 1975, p. 38, 39.



be investigated.

The planned doubling of production in the next ten years of the five- to ten-fold increase in three decades will need accelerated transfer of technology, massive financial investments, suitable legislations, intensive research, manpower training and development of institutions and other essential infrastructures... One of the weakest areas of aquaculture activities at present is extension services, which creates serious problems in the implementation of development programmes. There is an urgent need to upgrade the facilities for well balanced theoretical and practical training in these centers (for research, demonstration and training) to meet requirements for extension personnel... Information exchange has a vital role in a developing science-like aquaculture, particularly since the industry has to depend to a large extent on transfer of technology for its expansion... While it is generally recognized that massive assistance is required for rapid progress in aquaculture, the flow of development assistance in this sector has unfortunately been very insignificant..... In earlier years, small projects were useful to show the potential of the industry but now the need is for projects that are capable of demonstrating the technical and economic feasibility of aquaculture in order to attract investments of large scale development.<sup>7</sup>

In Hawaii's future lies a potential industry waiting for development. Aquaculture is still in the development stage in Hawaii. That means federal funds are coming into the state and boosting the economy. Research, Training, and Technology Transfer will supply 300 to 400 jobs for Hawaii's unemployed people. Hawaii may have a low priced food locally grown. Hawaii could possibly be the world's leading research facility.

Hawaii has the chance to finish the development stage and go into industry. If Hawaii goes into industry, she could be a research, training, and technology transfer center for the world.

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<sup>7</sup>DPED p. 10, 11



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PRAWN FARMING: A NEW INDUSTRY FOR HAWAII  
by Curtis Kawamoto, Hilo High School

The prawn, a small crustacean which is a delicacy to eat, is a good freshwater aquatic shellfish to use in aquaculture in the Hawaiian Islands. It is an ideal crop for Hawaii because prawns grow best in a tropical climate above 77 degrees F. Also, prawns don't take too long to reach market size, and they sell at a very good price. After about a decade, Hawaii has become the world's leading center for the prawn enterprise. I believe that the prawn industry would be good for Hawaii because it is a very profitable business, and will be very good for Hawaii's economy once it is perfected. For these reasons, I am writing this paper.

Results of Research

Hawaii's Commercial prawn aquaculture became possible in 1966 when biologists at the Anuenue Fisheries Research Center (AFRC) of the Hawaii State Department of Land and Natural Resources developed a practical mass larval rearing technique. The center had some selective breeding and ecotype testing of different varieties of prawns to find which would be the most profitable to raise in Hawaii.

The center has developed a pond system for the prawns to grow in. It consists of an unlined earthen pond with a sluice gate outflow system. The water quality is controlled by flushing rates, fertilizers, and oxygen releasing agents. The flow rates are increased as much as threefold to flush the pond of excess phytoplankton blooms, and decreased when the phytoplankton densities fall. The water depth of the ponds are kept at 3 to 4 feet high to allow moderate phytoplankton densities in the pond. The water is kept at this level to prevent the growth of benthic algae or aquatic weed growth, which would interfere with the harvesting of the prawns, thus raising the cost of production.



The new larvae are then placed in 5,020 gallon tanks, which contain the brackish water needed for the survival of the prawn larvae. The water that the prawn larvae lives in has to have an optimum salinity of 12 to 14 parts per 1000, with the optimum temperature between 82 degrees and 86 degrees F. The prawn larvae are stocked 150-230 individuals per gallon. One milliliter of water contains 500,000 to 2,000,000 single-cell algae. In static cultures where water is periodically exchanged, Artemia nauplii are provided at concentrations of between 5 and 15 nauplii per milliliter. Later, after 1/2 or 2/3 of the larvae stage has passed, they are fed minced fish flesh. This phase at the hatchery takes about 40 days and 50 to 60 percent of the larvae survive.

The farmers feed approximately 30 pounds of poultry broiler starter per acre per day, which represents a feed conversion ratio of 3 pounds of feed for every pound of prawn. The amounts offered to the prawns vary. If the food given to them disappears within 24 hours, their feed rate is increased; if some food is left back the feed rate is decreased. The prawns are then harvested every 2 to 3 weeks after an initial growth period of 7 months.

#### Problems Facing the Prawn Industry

The prawn industry in Hawaii is faced by many problems, problems that threaten to end this new industry, which if given time and patience, could become a very profitable business in my opinion. Although there are many problems, people have come up with many ideas and ways to solve these problems.

The first of these problems is the reduction of the cost of the producing of the post-larval prawn. Many organizations, private and public all over the world, are going through extensive cost reductions. The answer to this specific problem is the extensive AFRC research program. The program works on this specific problem, and functions in conjunction with it's commitment to furnish-



ing stocking material to Hawaii's prawn farmer. The program's main purpose is to achieve a shorter larval cycle to reduce operating costs and increase annual production. Other areas of research include controlling and optimizing environmental factors, nutrition, tank design, and flow characteristics, hatchery management, and selective breeding.

The second problem is the weather of Hawaii. The weather only allows the stocking of growth ponds once a year. The answer to this is the temperature control modification. The hatchery is now undergoing this to permit it to stock growth ponds all year long. When this modification is completed, multiple stockings are expected.

A third problem that faces the prawn industry is the debt that the industry has. Out of all the costs of production, 60% is used to pay debts, and the other 40% is for labor and feed. The solution to this problem is to increase the productivity of the living prawns. There was no organization to check on the diseases they can catch. The solution to this problem was the Aquatic Disease Services. Its responsibilities include responding to on-site production disease problems, research, and the cataloging of local aquatic diseases, and the inspection of export and import of aquatic products.

The last problem is that many mainland and Hawaiian wholesalers are reluctant to handle prawns because of erratic supplies and variation in the quality of the product. Using present blanching techniques, the shell-life of freshwater is approximately six days. The solution to this problem which seems to have the most promise is flash-freezing. This method increases the shell-life from six days to six-eight months.

#### Potential of the Prawn Industry

The prawn industry has a very promising future in the world. The demand



for prawn in the world far exceeds the existin supply. The price of prawn is about 8 dollars Wholesale. In the state of Hawaii, four possible markets have been identified: (1) hotels and restaurants, (2) schools, (3) military commissaries, and (4) such retail outlets as seafood markets and supermarkets.

### Conclusions

I feel that the prawn industry has great potential in the Hawaiian Islands. It could become very profitable once the problems are solved. Because the demand for prawn far exceeds the supply, it could become a great industry in the islands. It would be very good for Hawaii's economy, because it would produce more jobs. and bring more income into the islands.

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# THE DISEASES OF AQUACULTURE

by Bruce Bowen, St. Joseph High School

## Introduction

Disease and parasites in fish and shellfish populations pose a problem to the Industry. A lot of information about diseases of captive mount fish has been acquired in marine aquaculture. Although shellfish have long been cultivated by primitive methods for centuries, the significance of disease has only recently been appreciated. Current methods of disease control are inadequate.

More and more is being learned about disease in cultured shellfish populations. Marine aquaculture is becoming progressively popular, but there is one big obstacle in aquaculture. It is the major problem of disease.

A new technology for the treatment of marine fish disease including the many modifications of techniques used in fresh water hatcheries are developing, but the progress is slow. It should expand greatly in the next ten years.

As with freshwater fish diseases, many of the advances in understanding the role of marine fish diseases can be expected to develop from studies of fish held in captivity. This really helps in the infectious disease until the epizootic form which may sweep through aquarium populations. Or in the enzootic form can cause continued attrition of valuable specimens. Infectious diseases are often present in fish from natural habitats and may do well in artificial environments. This occurs because of increasing infection from fish to fish in a restricted body of water. This can also happen because of somewhat higher environmental temperatures, not enough space, food, and a consequent reduction in resistance.

Also, undoubtedly the stress amount of artificial environment, like an aquarium for cultivation, contributes to disease outbreaks. Diseases are more likely to be detected, because the fish in captivity are always subjected to more risk of trouble than there subject to in the open ocean.



A lot of things can effect fish held in captivity. For example: bacterial pathogens, and if there is high infectivity, it will be more harmful to the fish.

Two men in 1953, Openheimer and Kestiven had a lot to do with the reporting of fish diseases. These men reported that the most common external lesion was fin rot and bacterial tail rot.

A good example of this was in the study of the Atlantic Herring. The researchers kept the fish in captivity for 10 years, but most were studied for two years.

The scientists found out that there was a lot in the progression of erosion of the fish fins and tails. These fish also had real tiny hemmorages under the fish scales, and disorientation and the roughing and sloughing of the intigment.

There were two other prominent researchers; Anderson and Ridell. These two men have studied some of the other types of skin ulcerations and some different types of bacterial fin rot. These men also discovered that fish are infected with the "nibbling" disease, which caused the fish to bite their tails and caused their deaths within two days.

Another type of disease called "lymphocystis" which is the most common type of disease in marine aquaculture in both salt and fresh water. Some of the syntoms are; whitish nodules on the fins and on the fish's bodies. When this occurs, the disease affects the fish externally and internally. Internally, the fish has certain connective tissue which grows to a really big size. When the tissues have grown, a hyline capsule surrounds this enlarged tissue. On the skin, big lumps appear. This disease usually affects the fish in the summer and goes away in autumn. The fish which were affected by the disease, usually recover totally from it.

Another type of disease researched by Brown and Laired was a disease called "Velvet" disease. This disease causes hemmorages and adhesiveness of the gill laments, which affected their breathing in their gills. If the disease is severe the fish's skin gets patches of white powdery substances that are called "velvety patches". This disease is caused by dinofla agella.



A disease similiar to the "velvet disease" is called the "white spot disease", which is caused by cilia parasites. The effect of the disease is white spots on the fishes body, which sicker the fish and death can result.

A scientist named Kusuda, extensively studied an ulcer disease. This ulcer disease usually kills the fish a few days after the fish have been infected. The mortality rate of the fish infected is 98%.

A place in Japan, Mie prefecture, is an excellent place used to study marine aquaculture. Bacterial diseases like systemic vibrio or yellow tail, vibriu deseion ayu, bacterial dematis and ulcer disease.

### SHELLFISH IN MARINE AQUACULTURE

Researchers have found that the disease in shellfish are more disasterous than in fish aquaculture. For example, consider the "shell disease", which is prevalent among lobsters. The disease is caused by chitin-destroying, gram-negative bacilli. This disease causes the weakening of the lobster's muscles and shell and the lobsters than die in the winter.

In the United States shellfish culture has been sucessful in natural waters, except in the Delaware and Chesapeake Bays on the East coast. A disease, known as the "Delaware Bay" disease has been hurting the cultivation of clams.

A disease; laptosparidan protozoan Michinia nelsan has been studied by Andrews, a researcher. Andrews states that most of the Virginia Bay oyster beds have been destroyed by the disease. The oyster beds are usually infected during May and October. After the beds were infected, the oysters were dead in about two months. The rate of mortality is about fifty to sixty percent.

Because of the Delaware Bay disease, some other states have been affected besides Delaware. These states were Maryland, Virginia, and New Jersey. More and more aquaculturists are tired of the oyster beds being ruined, and they are searching for a way to make these shellfish resistant to diseases.

Markin, a researcher, said in 1961, "that the amount of disease in the oyster beds were due to having too many oysters in one section, and too many oysters are susceptible to too many diseases.



A lot of oyster diseases, or almost all of them, are dormant during some part of the year. A good example of this is a disease called Dermocystidium disease. It would be most active most always near the Gulf Of Mexico, but the Chesapeake Area will be free of the disease for half of the year. But in Virginia, a full crop of oysters can be lost in one summer alone.

Some of the diseases that hurt the production of oyster beds around the country could be helped. Hwatt suggested in 1957, that if some of the diseases were worse during the summer season, minimizing the number of summers that oysters are held in the enzootic period could be a solution, most by taking advantage of the high salinity areas.

Fungi diseases could be prevented more also. However, the size and age of the oysters help influence this. Some oysters about four months old aren't infected until this time, and the death rate is very low during the first year of the oyster's lifespan. But, the death rate increases as the oysters get larger and older. The best thing for an oyster producer to do is to find the largest oysters in the beds, then harvest your crop as soon as they are large enough to sell. The harvest should also be in the Spring if possible, since a lot of the oyster diseases are dormant during this time.

In the future, the world of aquaculture will be depending on artificial means of cultivation. Because of devastating diseases, artificial methods can be used to control the diseases, and the shellfish could be fertilized and production made more abundant for the world's supply.

#### SUMMARY

The science of aquaculture has been in the world for centuries. People have researched for new information to help the production of aquaculture. New techniques to help shellfish resist diseases have been developed. The world's oceanographers envision new artificial means in the future to help feed mankind through the science and industry of aquaculture.



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**Energy**



OFFSHORE PETROLEUM INDUSTRY  
by Sarah Feliciano, St. Joseph High School

ABSTRACT

The source of petroleum has become a national and even world wide concern. Petroleum has become a major concern for the United States today due to rising prices, for the cost per barrel. It furnishes the energy needed to supply the families and the business areas around the country, and also the refineries to produce it and sell it to various market places.

The offshore petroleum industry invades the recovery, processing and the delivery to market of the offshore oil which is located in some geologic structures of the continental shelf.



## Offshore Petroleum Industry

More than half of the fuel energy used in the world today is obtained from oil and natural gas, which is usually found with oil in the earth. More than two-thirds of fuel energy comes from oil and natural gas in the United States. These sources are important, but outside of this industry few people are aware of and are the basic facts of oil.

The Oil Recovery System is the mining processing and delivery to market of offshore oil located in the geologic structures of the continental shelf in selected areas of the world for the U.S. or world markets. System B for the recovery process is the recovery, processing and delivery to market of offshore oil which is located on the deep ocean structures about 6,000 feet or greater in selected areas of the world for selected U.S. markets.

The recovery, delivery and processing of ten million barrels per year on the continental shelf of California provides delivery to markets with cost price no greater than \$1.50 a barrel. In California the most important resources are building materials and oil. The output of oil has risen to over 50 million tons. California is the third in the United States for oil. The chief drilling areas are in the Southern part of Central Valley and in Los Angeles basin where Signal Hill is still covered with derricks. New wells



are being drilled off the shore at Santa Barbara and Long Beach.

Falling water is another source of part of the energy man employs, but most energy comes in chemical form. These materials are generally classified as fuels.

Petroleum fuel, also called oil is the liquid mineral which consists of a mixture of numerous hydrocarbons, oxygen, nitrogen and sulphur. It occurs in underground formations sealed over by strata. In some areas, the seals are not perfect and so oil seeps to the surface.

Oil was first tapped at its source. The oil industry has made a rapid expansion since the invention of the combustion engine and its application in the development of the automobile and airplane. It has also increased farther by the convenience of using oil in place of coal for heating and raising steam.

The entire increase in energy consumption in the world has been met by oil, gas, and coal. The use of energy will continue to grow and that of oil and gas will provide an increasingly large part of the total supply demand.

The great importance of oil arises not only from its large contribution to the total energy supply but also from its role as the liquid energy source and its versatility as a raw material.

Oil has made it possible for cars (automobiles), airplanes, trucks and tractors to maintain function. Ocean-



going ship now burn oil. An oil-driven ship can travel farther without refueling than a similar ship using coal.

Burned under the boilers of central stations, heavy fuel oil produces steam to turn the generators from which electricity flows to give machines power in factories, give homes and streets light, and to operate all other electrical equipment.

In the United States about ninety percent of the crude oil is sent to refineries to be made into fuels. The other ten percent is used for such things as lubricants, solvents and asphalt. Total energy from petroleum fuel is enormous and is a principal factor in the mastery over time, space and environment that has been achieved by man already.

Oil formation animals is a result of billions of years of decayed settling to the sea bottom which mingled with decaying vegetable matter and fine silts washed from river beds. This is the raw material from which crude petroleum started. All during this time dead organic matter was being transformed into petroleum and gas. Sediments continued to settle in the sea floor and were compacted into rock formation. Drops of newly formed oil and tiny bubbles of gas began to squeeze out of the muds in which generated into porous rocks near to either limestones or sandstones.

Resources include: 1) oil already produced 2) proved reserves 3) oil awaiting recovery by some improved production



methods and 4) oil which is yet to be discovered.

In early times, oil was used by men as an ointment, for waterproofing or just to make torches by dipping reeds and twigs on it. Crude oil skimmed from ponds was processed by primitive methods to make a product called kerosene.

New petroleum must be constantly found to replace that which has been used and to meet enlarging demands. The oil industry is a search that will never end. Sometimes great difficulties must be overcome to find oil, bring to surface and transport it to refineries and markets.

"Offshore drilling provides many illustrations of the fact that obtaining oil still presents many physical difficulties".<sup>1</sup>

"The petroleum industry has been a leader in applying science to business".<sup>2</sup> All major oil companies and smaller ones have large number of chemists, physicists, engineers and technicians on their staff.

Petroleum research is largely responsible for the great rubber industry. This industry is continuing to grow and expanding throughout the United States.

Oil is the vehicle or active ingredient of numerous sprays that have been used in agriculture. It's sprays keep herds healthy, kill orchard pests, retard budding and guard against losses from frost. From this oil has come household and industrial detergents.

"Oil companies range through all sizes",<sup>3</sup> each company



a part of the total economic activity. Large organizations undertake mass production, mass distribution and developments.

The oil business includes brokers, speciality companies supply and servicing companies. Brokers buy and sell oil. Speciality companies blend and sell oil products, chiefly lubricating oils and greases.

The oil business will expand and continue to grow rapidly. Prices to buy oil from other countries will increase and there is also a danger of oil leakages occurring.

My opinion is that the petroleum industry will always remain productive and behighly useful for the United States. Petroleum helps us to run our cars, lights stoves for cooking and many other important uses in the world today.

The future of offshore ocean mining will increase very highly and will have a very high demand for the world today. We the people of the United States will look upon oil as our major resource. Mining too will have a high demand. There will be more deep ocean drilling to see how much more oil will be found.

<sup>1</sup> Schackke, Stewart, Oil For The World, (New York: Harper and Brothers Publishers, 1960), p. 60.

<sup>2</sup> *ibid.*, p. 91.

<sup>3</sup> *ibid.*, p. 60.



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OCEAN THERMAL ENERGY CONVERSION: AN UPDATE  
by Annette Oishi, Pahoa High School

ABSTRACT

Ocean Thermal Energy Conversion (OTEC), now a familiar set of words to Hawaii residents has developed its potential greatly in Hawaii over the past four years. This potential has increased due to OTEC projects being designed and even being completed in the state of Hawaii.



## INTRODUCTION

Alternate energy sources have been looked into more lately because of the decrease in our energy producing resources such as oil. One of which is a type of solar energy called Ocean Thermal Energy Conversion (OTEC). This source of energy calls for conditions that make Hawaii a suitable site for such projects.

In my paper, I have researched on the general OTEC process, future projects such as the Seacoast Test Facility and OTEC-1, and the present experimental Mini-OTEC project at Ke-ahole Point in Kona.

## RESULTS OF RESEARCH

### The OTEC Process

Ocean Thermal Energy Conversion is a system in which electricity is generated from the ocean. A significant temperature gradient of surface water at about 70 to 85 degrees Fahrenheit and water below the 2000 feet depth at 40 degrees Fahrenheit or less is needed. A temperature difference of 35 to 40 degrees Fahrenheit is required between the surface and the depths. This temperature difference between the warm surface water and the cool deeper water determines the efficiency of an OTEC system.

One concept of OTEC is the closed-cycle system. It was developed by William John Macquorn Rankine and is known as the Rankine cycle. In this cycle, heat exchangers play an integral part. A fluid such as ammonia is heated in an evaporator by warm ocean surface waters. The



heating process turns the liquid ammonia, which has a very low boiling point, to vapor and the vapor drives an electricity-producing turbine generator. The vapor then passes into a condenser where it is cooled by deep cold ocean water pumped up from a depth of about two thousand feet below the surface. The cooling process turns the vapor back to liquid, the liquid is sent to the evaporator, and the cycle, now completed, begins anew. The evaporator and the condenser in an OTEC system are heat exchangers, which permit heat to be transferred between the ocean water and the liquid, either heating or cooling the ammonia.<sup>1</sup>

The efficiency of a closed-cycle system will not exceed one to two percent. This is low, compared to the thirty-five to forty percent of a steam turbine power plant. However, the fuel is free and practically inexhaustible in this system.

#### Ke-ahole Point

Hawaii has become greatly involved in the development of OTEC activities. Ke-ahole Point in Kona was chosen as the site to conduct these activities. Ke-ahole Point offers excellent water mass properties, bathymetry profiles, favorable weather conditions, high annual solar radiation, accessibility to transportation, personnel support, nearby public works, land availability and technical and industrial support. These factors make it ideal for both land-based and sea-based testing.<sup>2</sup>

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<sup>1</sup>Hawaii Natural Energy Institute's 1978 Annual Report, p.15.

<sup>2</sup>Hawaii Natural Energy Institute's 1978 Annual Report, p.16.



### Progress of OTEC Plans

At the end of last year, an OTEC-1 project was contracted to Global Marine Development Co. by the U.S. Department of Energy. These contractors are expected to "design, fabricate, convert/modify, assemble, test deploy, manage, and operate" OTEC-1. This \$42.7 million project involves the conversion of a government owned T-2 tanker into a test platform. The tanker had been selected because of lower technical risks as compared to the original concept of converting the famous Hughes Corp. Mining Barge. The floating platform will be moored 18 miles northwest of Ke-ahole Point to begin the testing phase. The tests will concentrate on the thermal performance of one megawatt heat exchangers, methods to prevent and remove corrosion, and the formation of biofouling. Cold water is to be brought to the surface through three 48-inch polyethylene pipes to a depth of 2,300 feet from the platform. It is expected to take 18 months to complete and an expected three years in operation, starting in early 1980.

Another project is the Seacoast Test Facility (STF) to be built at the Natural Energy Laboratory of Hawaii (NELH). NELH is expected to be the focal point for a diverse OTEC testing program over the next ten years. This onshore research and development laboratory is estimated to cost about \$6.5 million. Studies and experiments on cleaning, biofouling and corrosion of heat exchangers, as well as system component testing and evaluation will also be conducted there. Researchers will have an opportunity to simulate the actual conditions which future OTEC systems will be likely to encounter.<sup>3</sup> STF will consist of an onshore laboratory,



an administration structure, and electronic and machine shops. It will be able to pump deep cold water to the on-shore laboratory at a rate of 6,400 gallons per minute and warm water at a rate of 9,600 gallons per minute. The warm water pipes will be positioned approximately a 100 ft. below the ocean's surface. And the cold water will be pumped through a 28-inch polyethylene pipe extending one mile from the shore. A ten-year research program is planned for the facility.

The Mini-OTEC project which successfully concluded in December 1979 was stationed one mile off Ke-ahole Point. (near the NELH) This modern operational OTEC system was the world's first ocean-based OTEC system to generate more power than it consumed. On August 4, 1979, the project generated up to a sufficient 52 kilowatts within the first six hour test. Forty kilowatts were used to operate the plant rather than transmitting it to shore. The remaining 12 kilowatts were used for running test and measurement equipment. As mentioned before, the four month testing and operational project was a success. The experiment was financed by the State and County of Hawaii, Lockheed Missles and Space Company and Dillingham Corp.

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<sup>3</sup>Hawaii Natural Energy Institute's 1978 Annual Report, p.16.



### CONCLUSION

In researching Ocean Thermal Energy Conversion, I have learned the great possibilities this process has as an alternate energy source for Hawaii. Projects such as Mini-OTEC and OTEC-1 are just scaled steps looking toward a giant OTEC project. And with the successful completion of the experimental Mini-OTEC in December we have moved a step closer to making Hawaii the Ocean Thermal Energy Conversion center of the world.

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A WAVE-POWERED GENERATOR FOR HAWAII  
by Maia Zaiger, Konawaena High School

ABSTRACT

The need for exploring all possible energy sources is briefly discussed. The nature of the vast amounts of energy contained in wind generated ocean waves and the interest in using this energy for electric power generation is outlined. An idea for a compressed-air electric generator using the mechanics of natural blow-holes is described and illustrated.



## A WAVE-POWERED GENERATOR FOR HAWAII

### INTRODUCTION

The period from now to the end of the century must be one of energy transition --away from oil as the world's dominant fuel.<sup>1</sup> Not only will the demand for oil exceed the supply but Hawaii must import 100% of its energy needs in this form. Any political disturbance or boycott by oil producing nations could result in the halting of deliveries of oil to Hawaii. This would result in severe hardship for our people. Our growing need for electric power is fast outstripping our means of producing it, but further expansion of our current energy sources poses a dangerous threat to the environment. We must therefore convert to alternate sources of energy as soon as possible to become independent of imported oil.

There are several promising sources of alternate energy for Hawaii such as geothermal, ocean thermal energy conversion (OTEC), solar heating, and wind generators. Every encouragement should be given to the research, development and installation of these. Also the investigation into the potentials of wave-powered generators of electricity for Hawaii should be pursued.

### STATEMENT OF THE PROBLEM

At present, OTEC seems the most promising method of

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<sup>1</sup>Paul Basile, The Coming Energy Shortage, p. 470.



generating electrical power;<sup>2</sup> but to be economically feasible, huge power plants costing hundreds of millions are required.<sup>3</sup> Additionally, deep water, protected from storms, such as off the Kona Coast are needed. However, there are considerable stretches of shoreline in Hawaii where these conditions are not met, for example, the rocky windward and northern coasts exposed to the trade winds. Extracting energy from the ocean's surface waves has long fascinated scientists. The engineering problem is being able to design economically feasible structures for harnessing the power from the forces in the motions of waves. Therefore, it is the thought that all of the various approaches to tapping the ocean's energy for power generation should be studied and considered for use in Hawaii. The subject of this paper is to briefly discuss the vast amounts of wave energy available on the windward shores of Hawaii and to describe a possibly feasible idea for small-scale wave generators to harness this energy.

#### WAVE ENERGY

Wind-generated wave motion on the open ocean consists principally of an up and down motion. In shallow water this motion decreases and is translated to strong to-and-fro motions.<sup>4</sup> When the force of the wind drops, the waves already in motion

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<sup>2</sup>Economic Indicators, OTEC, p. 27.

<sup>3</sup>Reed Millard, How Will We Meet the Energy Crisis, p. 142.

<sup>4</sup>Elizabeth Clemons, Wave, Tides and Currents, p. 48.



die out slowly. These troughs and swells travel for long distances, even thousands of miles, until they reach shore. This explains the almost continuous in-and-out surge of water on nearly all exposed ocean headlands throughout the world.<sup>5</sup> We find these trade-wind generated waves almost continually rolling in on the windward and northern shores of Hawaii. When these wind-generated waves enter shallow water at an angle, refraction causes the entire wave to turn toward shallow water.<sup>6</sup> The slightest irregularity in the sea floor influences the path of incoming waves, focusing or converging the energy at certain points on the shore.<sup>7</sup>

If wave-powered generators were to be considered for Hawaii, the shoreline areas generating consistently large waves would be the sites of choice. The kinetic energy per unit area of a wave is proportional to the square of the waves height. Waves of two meters have four times the kinetic energy of one meter waves.<sup>8</sup>

The energy brought to bear on stationary objects near the shore by breaking waves is tremendous. Forces of 6,350 pounds per square foot have been recorded.<sup>9</sup> The energy in only a one meter wide front of steady, two meter high waves could

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<sup>5</sup>Lester Del Rey, The Mysterious Sea, pp. 178-9.

<sup>6</sup>David A. Ross, Introduction to Oceanography, p. 217.

<sup>7</sup>Tony Loftas, The Last Resource, p. 143.

<sup>8</sup>Peter K. Weyl, Oceanography, p. 168.

<sup>9</sup>Loftas, p. 144.



supply the electrical needs of twelve homes; a one kilometer front could yield enough power for a city of 85,000 people.<sup>10</sup> A large floating rectangular structure, the size of a super tanker, is being built to generate electricity off Britain. Each generator will have 20 to 40 vanes over which the waves roll. Edinburgh University's Dr. Stephan Salter says, "One of these 50 megawatt generators, placed every 100 miles along the eastern edge of the Atlantic, would satisfy the electrical needs of all of Europe, cleanly, safely and forever."<sup>11</sup>

#### A COMPRESSED AIR GENERATOR

There are numerous natural blow-holes along exposed coasts where lava flows have entered the ocean in Hawaii. The lava has been eroded on the underside by wave action until an opening in the lava has been reached. When a wave recedes, a considerable volume of air is sucked through the opening under the lava. When the next wave surges shoreward, this trapped air is compressed, and it and water are hurled to heights often to over 50 feet. As one atmosphere in excess of normal atmospheric pressure would be required to lift water about 30 feet, at least three atmospheres of pressure (or about 44 psi) would be needed to lift water over 50 feet if friction and the deceleration due to gravity are considered. This is sufficient pressure to power a compressed air engine that could drive an electrical generator.

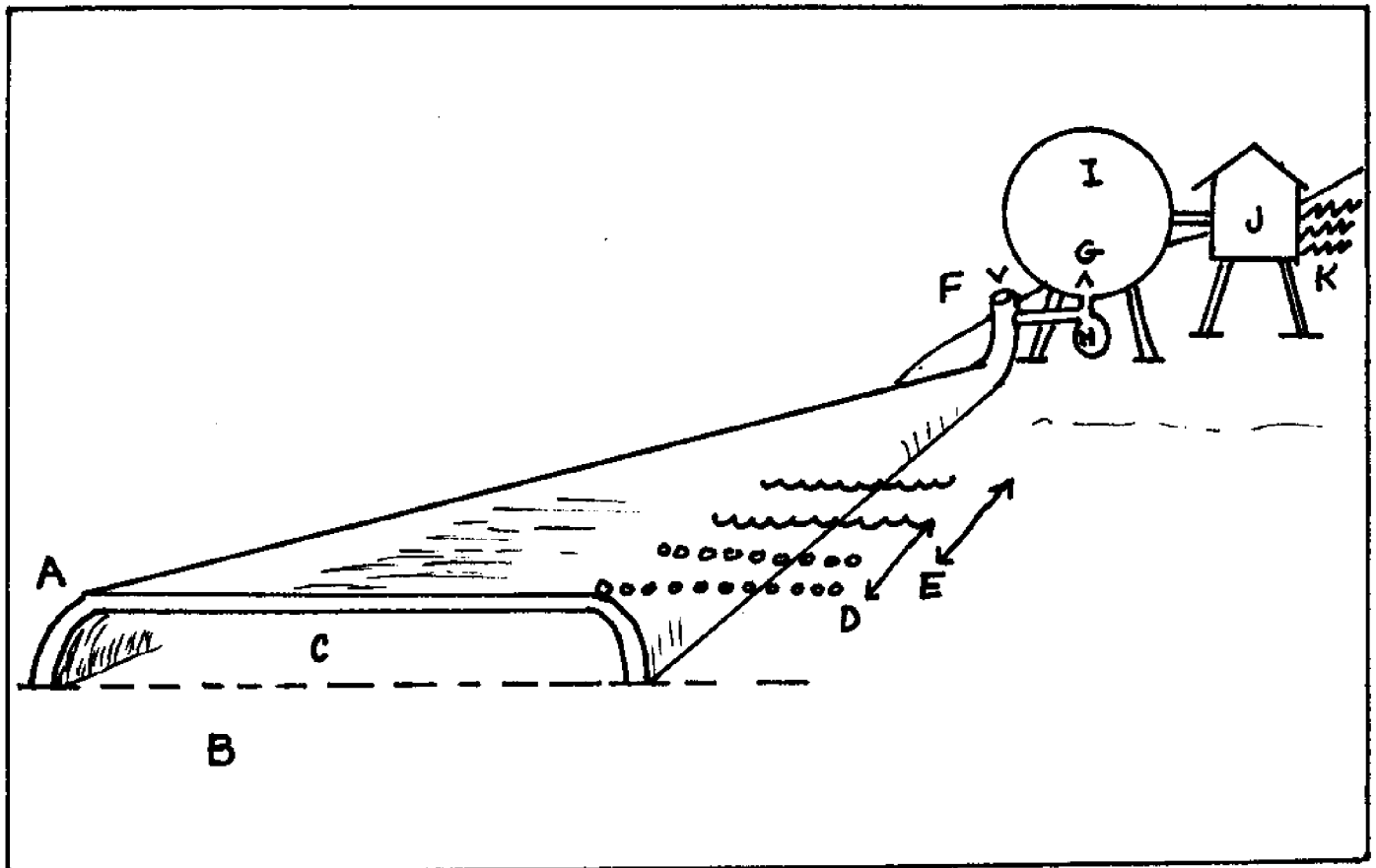
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<sup>10</sup>David Scott, Wave Power Tapped by Nodding Ducks, p. 16.



<sup>11</sup>Gary Soucie, Plugging in the Ocean, p. 17.



Figure 1. A wave-powered electric generating plant



# LEGEND

- |   |   |
|---|---|
| A. Reinforced concrete flattened half-cone  | F. One-way air replacement valve          |
| B. Lava sea-bottom  | G. One-way compressed air retaining valve |
| C. 2 m opening<br>(if average wave 2 m)   | H. Water trap                             |
| Height of crest <br>and trough  | I. Compressed air tank                    |
| D. Low tide   | J. Compressed air generator motor         |
| E. High tide  | K. Electric transmission lines            |



It would therefore seem possible that a scientifically engineered, horizontally positioned, flattened half-cone, constructed of reinforced concrete and firmly anchored on a solid lava sea floor, would be able to trap a large volume of air for compression by incoming waves. This air would be brought ashore via large pipes to drive a compressed air-powered generator. If research showed that the facility could be made storm proof, and the cost of installation and operation during its expected life would be less than the construction, operation and fuel costs of a conventional plant of comparable generating capacity, the possibility of harnessing wave energy as an alternate energy source would seem likely. (See Figure 1.)

#### EXPLANATION

The energy of the advancing wave is transferred to the air inside the cone by compressing it into a smaller space. The energy is released when the air is again allowed to expand inside the cylinders or vanes of the electric generator motor. When the air is compressed by the advancing wave, the air replacement valve (F) automatically closes. When the pressure of the air in the cone exceeds the pressure inside the compressed air tank (I), the compressed air retaining valve (G) opens to admit additional high pressure air.

When the wave recedes, the pressure inside the cone would fall. When it equaled the pressure inside the tank (I), the retaining valve (G) would close. When the pressure in the cone fell below outside atmospheric pressure, the air replacement



valve (F) would open to automatically admit more air to be compressed by the next advancing wave, completing the cycle.

The speed of the generator motor (J) is regulated by a governor. Multiple generators could be employed so that during periods of low pressure, due to fewer or smaller waves, generation could continue by cutting out some of the generators. During periods of strong wave action or periods of low demand, the excess electricity generated could be used to decompose water to produce hydrogen fuel. This hydrogen could be sold or used to power a conventional steam generator during periods of low wave action or periods of peak demand.

#### CONCLUSION

It is felt that large (1 to 2 meter) waves breaking on the rocky, wind-exposed shores of Hawaii could be harnessed to provide substantial amounts of electric energy. Being in the open ocean near the equator, Hawaii's tides are small. The device could not operate if the tides were large. Since the cone could be built to any degree of strength to withstand occasional storms, and all parts likely to corrode would be onshore, these problems common to surf battered coasts should be reduced. Environmental impact would be only visual, and this could be minimized by landscaping the onshore site of the generating plant. Also, as high surf, rocky coasts generally have few economic or recreational uses, the plants generating would not remove land for commercial or residential use. Lastly, the idea is submitted without any real knowledge of the



engineering, economic or scientific limitations that may make the device unworkable.

#### ACKNOWLEDGEMENT

While I had the idea of harnessing the energy of blow-holes, it was my Father who thought the idea had merit and helped me solve the design problem of storing the compressed air.

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THE CONVERSION OF OCEAN WATER INTO HYDROGEN  
THROUGH THE USE OF WIND POWER  
by Benjamin Chun, St. Louis High School

Abstract

Hawaii is dependent on imported petroleum for most of its energy requirements. In the event of a major energy crisis, Hawaii must be able to develop alternate energy sources. Wind energy can be used to supply a portion of this energy need. In order to store this wind power, a method was conceived whereby the energy would convert the ocean water into hydrogen through electrolysis. Hydrogen is an excellent fuel source and could help fulfill Hawaii's energy demands.



## Introduction

Hawaii is dependent on imported petroleum for 92% of its energy requirements. In the event of a major energy crisis, Hawaii would be in a serious dilemma. Gasoline, at the present time, costs as much as \$1.20 a gallon. This price is by no means fixed and is sure to rise again. Hawaii desperately needs to become self-sufficient, free from the outrageous price of petroleum.

The problem is that Hawaii geologically is volcanic and has no fossil fuel deposits. The only alternative is to develop the other natural resources. Out of these resources, wind power has the most potential. It is both clean and operable in almost any weather.

A wind generator is ideal for Hawaii because of the trade winds which produce 16+ mph winds 70% of the time.( The study basically deals with Oahu. )<sup>1</sup> Also Hawaii is especially suitable due to the abundance of water. This water can be converted into the cleanest fuel known, hydrogen. The energy gained from the wind generators could be used in electrolysis to break the water apart and store the hydrogen. Water is made up of two elements, oxygen and hydrogen. The oxygen would be given off as a waste product. Such a system could be located on Oahu at Kahuku.

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1. D. Richard Neill and Patrick K. Takahashi  
A Report on Wind Energy Applications Network for Hawaii



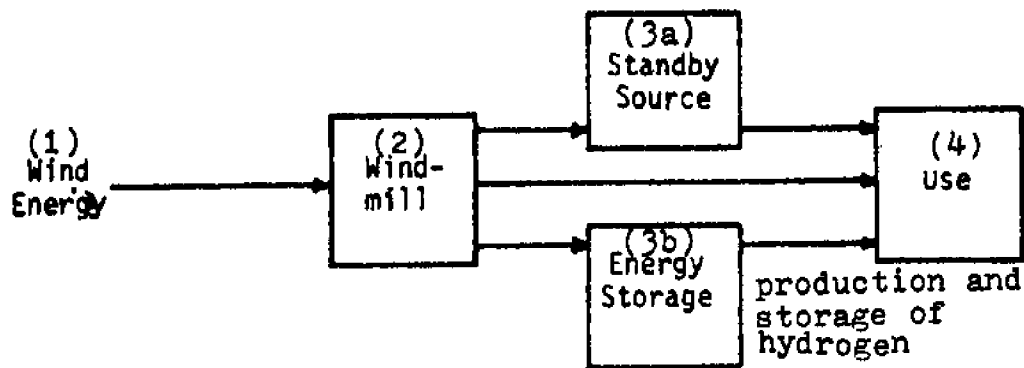


Fig. 1 Basic System Diagram

In the diagram: (1) The Wind Energy turns the propeller of (2) the Windmill which produces electricity. The electricity can go to (3a) a Standby Source--other energy delivery systems or (3b) an Energy Storage System--an example is the production and storage of Hydrogen.\* Eventually (4) the energy is used.<sup>2</sup>

#### Type of Wind System

The wind system envisioned for this study is a generator using a double-bladed, 24 ft. diameter propeller. This generator assuming 70% efficiency should produce about 10,650 watts in a 25 mph wind.<sup>3</sup> This is the reason for a large propeller. A large propeller is designed to operate in high winds and will not function in low winds. On the other hand, low winds do not produce much energy. A large propeller will produce more energy.

The wind generator will be mounted on a tower, to free it from the obstructions of trees and houses.

To make wind power a feasible source of energy, an array of these would be needed. A single generator is fine for a house, but it would be inadequate for large scale energy needs. These generators would be known as a "wind farm."

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 2. D. Richard Neill and Patrick K. Takahashi, A Report on Wind Energy Applications Network for Hawaii  
 3. John Prenis, Energybook 1, pg 10



## Application to the Ocean

The energy obtained from the wind could be used to produce hydrogen gas from water pumped in from the ocean. The wind generators for the system would be located on the coast, very near to the ocean. A large number of wind generators would be used to supply the energy needed to convert the water to hydrogen.

The system starts by pumping the sea water into a sealed container where it will be subjected to electrolysis. Electrolysis is the process in which water is separated into its two components, hydrogen and oxygen, through the use of positive and negative electrodes. Unfortunately, this process is not commercially practicable nor is it efficient. To make it efficient, the temperature is raised to 350-400 degrees F, and the pressure to 200 atmospheres. The efficiency increases to as high as 95%.<sup>4</sup>

An added benefit of this high temperature high pressure electrolysis is that the hydrogen gas can be stored directly in pressure tanks without a compressor. This saves both money and time.<sup>5</sup>

This wind generator system has already been researched, demonstrated and promoted by a group at the Oklahoma State University.<sup>6</sup> The only flaw is the loss which occurs during storage. More than half the power is consumed in storage.

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4. Hawaii University, College of Engineering, A Study of Wind Energy Conversion for Oahu, pg 5-4

5. E.F. Lindsley, "Hydrogen Power", Popular Science, March 1975, pg 90

6. Hawaii University, College of Engineering, A Study of Wind Energy Conversion for Oahu, pg 5-4



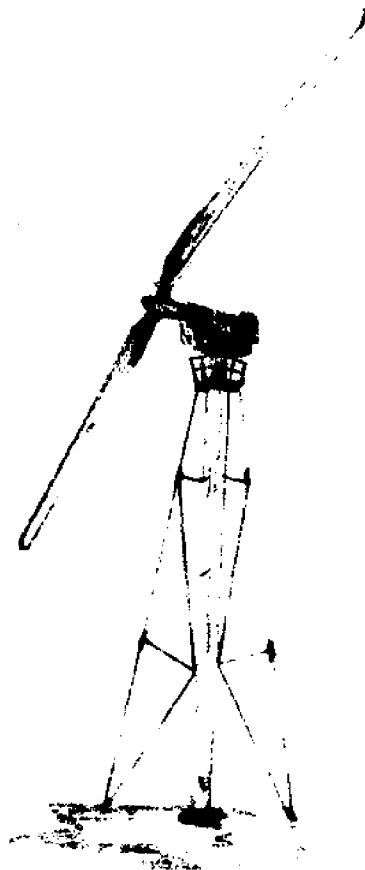


Fig. 2 This is a double-bladed wind generator.

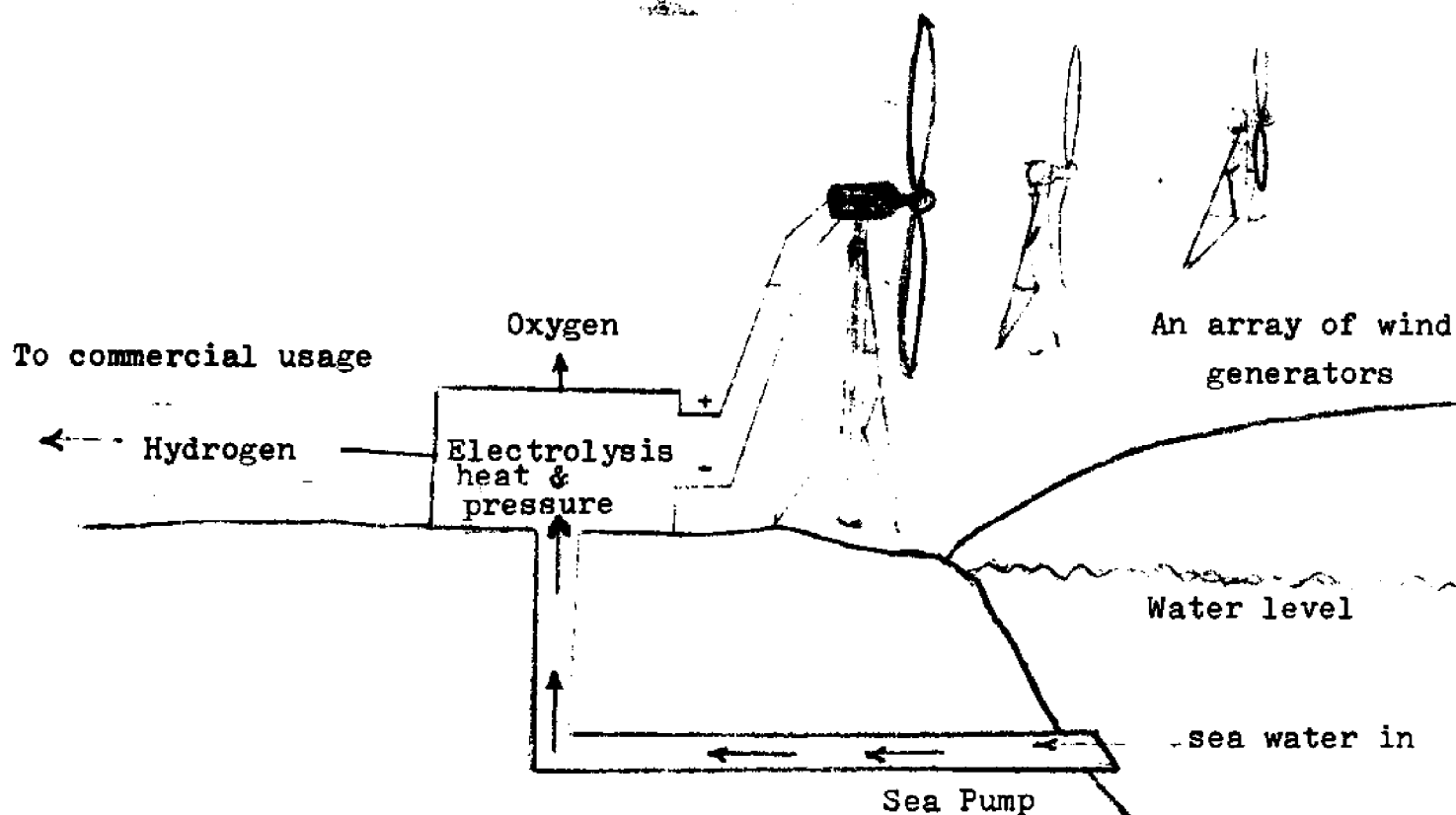


Fig. 3 Process of using wind generated energy to electrolyze sea water to produce hydrogen. Oxygen is a waste product.



Hydrogen is an excellent fuel source for a number of reasons. First, it is non-polluting. Hydrogen gas in combustion converts back to pure water, leaving no harmful residue. Secondly, it is man-made. When the natural resources, oil, coal, and natural gas are depleted, hydrogen can still be used as an energy source. Hydrogen is also very powerful. It packs the most energy per pound than any other fuel currently known. Finally, hydrogen could be used as a substitute and/or an additive for many petroleum usages. The hydrogen gas can be combined with other organic materials to make fuels such as methane.<sup>7</sup>

A virtue of converting the wind energy into hydrogen is that it is comparable to putting money in the bank. Wind energy comes in spurts and could be converted into hydrogen whenever it is available, regardless of the need at that time. The hydrogen would be stored and then later piped to where it is needed or where the demand is the greatest.<sup>8</sup>

Hawaii is the sound place for a wind generator-hydrogen conversion system. Hawaii is the center of steady trade winds, a constant energy source for the wind generators, and is encompassed by the ocean. The ocean is a key component in the derivation of hydrogen.

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7. Jim Pearson, Hawaii Home Energy Book, pg 149

8. E.F. Lindsley, "Hydrogen Power", Popular Science, March 1975  
pg 89



### Location of the Wind Generators

The most important element in a wind generator system is its location. The system would require consistent winds while being near the ocean.

On Oahu, there are several possible areas, but a wind generator situated in Kahuku shows the most potential. The average wind velocity at Kahuku is 25 mph. The trade winds blow 90% in the summer and 50% in the winter.<sup>9</sup> There is a large amount of possible energy to be tapped at Kahuku. Kahuku is also directly on the coast, a must for hydrogen conversion.

The other sites have been ruled out because of the lack of accessibility by good roads (Kaena Pt.), recreational facilities nearby (Kawaihoa Pt.), and the necessity of water to make the system operable (Kolekole Pass). There were four possible sites on Oahu.

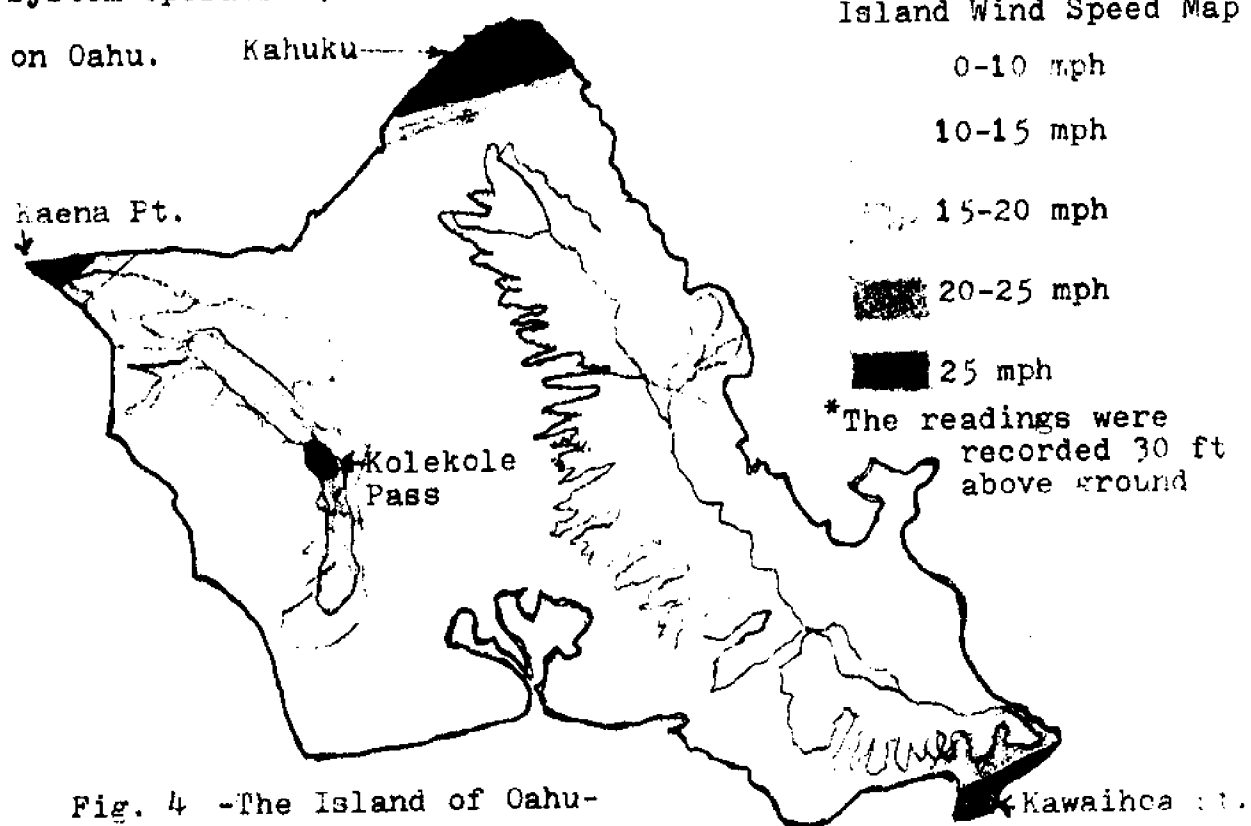


Fig. 4 -The Island of Oahu-

9. Jim Pearson, Hawaii Home Energy Book, pg 102



## Conclusion

The energy crisis continues to loom ahead. The price of gasoline will surely rise to \$2.00 or \$3.00 a gallon. Hawaii is almost completely dependent on imported oil. Suppose this oil supply was cut off. What would happen? Of course there would be gas rationing program for a while, but then what?

Hawaii must have alternate sources of energy. The potential for wind energy used to electrolyze water is there. This system is far from a " Buck Rogers " idea. The technology is available. Some companies presently have plans to construct a wind turbine generator at Kahuku. The U.S. Department of Energy is now considering a wind farm program for Kahuku and other primary wind site areas in Hawaii. Another program under examination is the possibilities of hydrogen generation by wind power.

Hawaii has all the advantages, the constant trade winds and the access to the ocean. A system of wind generators producing hydrogen could lessen Hawaii's dependency on imported petroleum.



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# Economic Potential of the Sea







FISHERIES  
by Susan Harlocker, St. Joseph High School

A fishery is an area which has an abundant supply of fish for the purpose of commercial fishing. Rules limit the size and amount of fish that may be caught, and the fishing season.<sup>1</sup> This type of fishing is done as a way of life and a way of earning a living by many people of the world. The operation can involve anyone or any amount of people ranging from one man in a small rowboat to a group of highly experienced people belonging to a private or governmental enterprises.

Fisheries involve the capture and processing of sea, coastal, and inland aquatic animals and plants, to be used for human food, animal food, or industrial products.<sup>2</sup> As the world population increases, more and more research is done on the ocean and its potential food supply. Now that food resources of land are not sufficient to meet the needs of the entire population, it has become necessary to look for alternatives.

A profitable area in the fishing industry is the harvest of sea plants. From a square mile of sea, an average of 13,000 tons of vegetation can be produced annually. The world totals probably five times the amount of vegetation harvested on land.<sup>3</sup> The most important water plants are algae. Seaweed can either be harvested from the water or collected from the shores. In many countries algae is used as human food, food for cattle, as fertilizer, and as a raw material for certain industries.<sup>4</sup>



Sea animals make up the major source of food for humans processed by fisheries. The most important of these are fish. Fish have always been the most common source of sea food. Two types of fish are caught. These are demersal, living at or near the bottom of the sea, though sometimes found in midwater, and pelagic, living in the open sea near the surface.<sup>5</sup> Reasons why the fish catch is so great and the most common are that they are more abundant than marine mammals, they are more widely distributed, and they are less elusive. In most parts of the world an average fisherman with an average vessel and gear catches a few tons of fish within a day's work. Fish are also easier to prepare, preserve, and market than mammals.<sup>6</sup>

Shellfish, another common catch of fisheries, make up more than 90% of the total animal life in the sea. The most common shellfish used as food are oysters, clams, scallops, lobsters, shrimp and squid.<sup>7</sup>

Sea mammals that are commercially useful include whales, dolphins, seals, sea lions, walruses, and sea otters. Although they are very valuable in the use of sea food and industrial products, their harvest is severely limited due to their small population and low rate of reproduction.<sup>8</sup>

In the fishing industry there are varying methods by which fish and other sea life can be captured.

The principal method of capture used by commercial fishing is snaring. Traps used in snaring range in size from small circular hoop nets to large set traps. These traps are made from fins, wire, nylon, and cotton webbing.<sup>9</sup>



There is great variety in the types of nets used in fisheries. Trawl nets are huge bag-shaped nets which are weighted along the bottom and have a mouth held open by a wooden beam or metal frame along the top. In bottom trawling, the trawl nets are dragged along the bottom of the sea and used to catch flounder, king crab, shrimp, and other ground fishes. The gill net which floats atop the water, is designed so that when a fish swims into it, then tries to back out, its gills are caught in the net. The most successful of all snaring techniques involves the use of a long net which is drawn in a circle around the school of fish being pursued. This type of snaring is called seining.<sup>10</sup>

Another method used by the fishing industry is luring, also referred to as trolling. In this process, the fishermen trail hooked, attractive lures which are attached to the boat by lines. These lines are arranged in such a way so that they do not tangle with each other.<sup>11</sup>

Attacking is the third basic way of capturing sea animals utilized by commercial fishermen, mainly those in pursuit of swordfish or whales. Harpoons attached by main lines are shot by guns or thrown by hand. Harpoon guns have now been developed in such a way that when they are shot into the animal, they send off an electrical shock that kills the animal.<sup>12</sup>

The fundamental processing of all fish is basically the same. They are prepared by grading, cleaning, and cutting. Then the filleting machines take over. In some instances, hand packing is done. A small percentage of all processed fish is smoked or cured.<sup>13</sup>



About 35% of the United States fishery catch is processed as fresh and frozen fish.<sup>14</sup> Freezing keeps fish longer and in better condition. It helps prevent the waste of this valuable food source.

Slightly more than 20% of the harvested fish are canned.<sup>15</sup> This is a more convenient method of packing when it comes to the storing fish at room temperature.

About 45% of the fish are manufactured into by-products or used as bait.<sup>16</sup> Scraps and waste from fish contain much protein and are used as animal food.

Even though over 70% of the earth is covered by water, only a fraction of 1% of human food is fish.<sup>17</sup> Less than 22 pounds of the fish caught or landed is consumed per person annually, taking the world population as a whole.

Gradually we are beginning to realize the great potential the ocean has as a food source. The total world catch has greatly increased to 14 million tons in a period of less than twenty years. This increase is largely due to the developing technology of fishing industries. Among these developments are improved boats, gear and equipment, electronic devices which are used to find fish, and developing fleets and techniques. An example of boat improvements is the factory ship, a vessel that can go to sea for two or three months. During this time she can both fish and process her catch on board. The one major drawback of this is that trained managers and technicians are often reluctant to leave their families and homes for such a long period of time.<sup>18</sup>

Accurate knowledge of the world's harvest of fish is not available because of the many people who fish on coasts for their own use. But an annual tabulation of the world catch by fisheries is made by



the Food and Agriculture Organization of the United Nations. By the late 1960's the FAO calculated an approximate 130 billion pounds of sea food were being harvested annually. The greatest catches were made by the People's Republic of China, Norway, the United States, Japan and the USSR. Spain, India, Canada, and Iceland accounted for about 2% or 3% each of the world catch.<sup>19</sup>

Even though the fishing industry has greatly increased it's harvest and production, much of this food is going to the wrong countries. Underdeveloped countries in need of food do not have a greatly developing fishing industry as do the richer nations, less in need. In the period from 1938-1957, Northern Europe's fishing industry increased the catch by 80%, while Asia, with a great population in need of food, had only a 30% increase in their fishing industry.<sup>20</sup>

Even though we can now look at the ocean as a source of food that the world can depend on, we must still deal with it in a wise, careful manner. If we are too careless with it, it could diminish rapidly and leave us with nothing. A fishery will supply the protein and needs of a certain number of people. If the number of people dependent on this system becomes excessive, then it will slowly be destroyed. If the rate of harvest from a fishery exceeds the rate of reproduction of its organisms, the supply will decrease and eventually collapse.<sup>21</sup> Weather, disease, and other natural conditions can also be the cause of destruction of such a system.

There are far greater food supplies available in the sea than can be believed possible. Nobody knows how long mankind can depend on the resources of the sea but it is a challenge to find out. we must learn to increase these resources where they are needed most.<sup>22</sup>



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SEAWEED: IS THERE A FUTURE FOR IT  
by Trevor Jackson, Waiakea High School

INTRODUCTION

Every day our population steadily grows larger. Approximately 200,000 babies are born each day. At the going rate, we are expected to have a worldwide population of approximately 7.5 billion by the year 2000.

As it is right now there is a food shortage everywhere. You are always hearing of starvation in various countries, children dying of hunger before they are 5 years old. If we are having food problems now, imagine what it is going to be like 20 years from now.

If we want to control hunger, we just simply have to find new sources of food.

Our knowledge of the ocean is growing rapidly, with it comes the knowledge that the ocean has many unexplored resources. We are slowly learning how to use to our advantage the sea and her contents.

The sea (which covers 70.8 percent of our earth) is where man is now looking for new sources of food to satisfy the growing population.

Seaweed is just one of the many possible food sources we are learning about. I picked seaweed as the topic of my reasearch report because I feel it is one of the more important resources which needs to be explored to it's full extent.



## SEAWEED: IS THERE A FUTURE FOR IT

Kelp, the fastest growing type of seaweed, is able to grow up to two feet per day under ideal conditions. Kelp is the main type of seaweed the United States harvests regularly. There are many reasons for which we harvest kelp. The main reason we harvest it is because it contains large amounts of algin. Algin is what holds the plant together against the battering of waves. We use algin in many manmade products. It is used for strengthening ceramics, to improve the consistency of plaster, to thicken ~~en~~ jams and sauces; it puts the head on beer, makes icecream smoother, adds permanency to ink, and even to coat writing paper.

Kelp multiplies in the spring, giving off millions of spores every minute, which drift with the tide to make the kelp beds larger every year.

Kelp beds are harvested on the average of 7 or 8 times a year. Kelp is harvested by large barges with blades designed to cut the surface canopy of the kelp beds. The legal length of cutting the kelp is to 4 feet below the surface, which is approximately 10 to 60 percent of the whole plant depending on the depth of the water.

Seaweeds in general are good sources of iodine, and vitamins A, B<sub>2</sub>, B<sub>12</sub>, and C.



Seaweed has no real distinct flavor, unless it is dried or eaten in large amounts. It has been used as a feed supplement for animals in the United States for over 40 years. Livestock do not like the flavor of seaweed right away, but get used to it. Cattle will not normally eat it at all. It is also used as fertilizer. It has about the same amount of nitrogen as manure, but less phosphate and more potash.

The navy is looking at seaweed as a possible source of energy. The seaweed is placed in large vats and allowed to rot producing methane, a gas which can be burned to produce energy. The sludge which is left over from this process can be sold as a commercial fertilizer.

Seaweed production in the United States is mainly centered around California and the New England coastal areas. Irish moss (one of the red seaweeds) was the first to be harvested regularly by the United States. It is mainly used to thicken foods.

There are three main types of seaweeds that are regularly used. The brown seaweeds, the red seaweeds, and the green seaweeds. The brown seaweeds are not usually used as food. They are more important in the production of algin. The red seaweeds are the ones more important as food, but are also used to make extractives, the agars and carrageenins. The green seaweeds are used the least of the three.



There are 2 or 3 green seaweeds regularly used, mainly used in soups and salads.

Although seaweed is low in energy and protein, it is an excellent source of trace elements. Some types of seaweed have up to 300 times more iodine and 50 times more iron than whole wheat. The vitamin and mineral content of seaweed makes it valuable in the prevention and treatment of deficiency diseases. Whaling ships in the 19 century used seaweed to prevent scurvy.

The United States harvests approximately 900,000 metric tons (~~a~~ metric ton is equal to 2204.6 pounds) of seaweed per year. Only a small amount of that harvest is used for food. The other portion is used for feed for livestock, and fertilizer. Hawaii alone uses more than 40 different kinds of seaweed in various foods.

People in the Eastern Hemisphere value seaweed as a food far more than the people in the Western Hemisphere.

Japan, the world's principal user of seaweed, harvests about 80,000 metric tons per year. By far the majority of it is used for food. Japan is also the only country making full use of these resources. One third of the seaweed in Japan is "nori" (laver). The cultivation of laver in Japan constituted the only really substantial seaweed industry in the world. In 1960, 57 percent of all the area under culture in Japan for any kind of marine



product--animal or vegetable--was given over to laver, and 82 percent of sea-farm workers were engaged in this activity.

Utilization of seaweed as a food source has increased over the last few years. But as it is, seaweed is not going to solve the worldwide food problem, unless more progress is made to learn about it.

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## AQUACULTURE IN HAWAII: A POTENTIAL SUCCESS by Karen Ide, Waiakea High School

Aquaculture is defined by the National Oceanic and Atmospheric Administration as "The culture or husbandry of aquatic animals or plants by private industry for commercial purposes or by public agencies to augment natural stocks."<sup>1</sup>

Aquaculture in Hawaii dates back for over 800 years. There were more than 200 fish ponds throughout the Hawaiian Islands which were used for raising fish and shellfish. Types of fish raised included mullet, awa, aholehole and others. Shellfish included Hawaiian crab, oysters and shrimp. Cultured animals were raised mainly on naturally supplied food but Hawaiians sometimes fed the stocks additional food such as taro. The success of ancient Hawaiian fish ponds proves that aquaculture is a promising industry for Hawaii.

Modern aquaculture is practiced in seawater, (also called marine aquaculture or mariculture), brackish water and fresh water. The location of the farm depends on the requirements of the species being raised and the technology involved in production. There are five main categories of aquaculture. The first is the release and recapture method. In this method, young are produced in hatcheries and released into their natural environment. After maturing, they are harvested through capture methods or during natural migration, such as salmon culture on the mainland. No examples of this method are used in Hawaii. Another is pond culture, where animals or plants are confined and raised in natural dirt, concrete or specially constructed ponds. This is the most widely used form of aquaculture in the world. The cage or basket culture confines the stock in wire or net cages which are supported in large bodies of water. Another method is raceway culture, where stocks are kept in trays through which rapidly flowing water is passed. This method is costly but the



amount of control over nutrition and water quality is great. An example of this method used locally would be the raising of oysters. In the closed, high density system, stocks are confined to a container through which recycled water flows.

Hawaii's three major sources of income include the federal government, tourism, which is centered on Oahu, and agriculture, which consists mainly of sugar and pineapple. Hawaii's agriculture, concentrated mainly on the neighbor islands is not expanding. In fact, many plants were recently phased out, causing unemployment. Aquaculture can serve as an ideal alternative. Hawaii is one of the few places in the United States to carry out large-scale aquacultural programs. Hawaii's location gives us the advantage of using western technology and the East's thousands of years of experience in aquaculture. Hawaii can make use of vacant land and provide additional or alternative uses for bodies of fresh water, salt water or ground water. Aquaculture will also help state and county programs to develop new and needed industries in Hawaii. Aquaculture could also supply Hawaii's needs for aquatic food products and provide a world-wide export product. Hawaii's dependence on imports from the mainland and other countries would decrease and Hawaii's economy could be diversified, which in turn would provide jobs for many. "In Hawaii, approximately 30 million pounds of sea food is consumed each year."<sup>2</sup> Less effort is required to sell sea food because it is consumed by people of Hawaiian-Pacific heritage and tourists.

Approximately 25 different species of animals have been tested in aquaculture research in Hawaii. Out of all species three categories were formed: species such as mullet and milkfish, which produce large amounts of low-cost food protein when mass-cultured; species such as prawns, which provide moderate to high priced food to create employment, diversify the economy and help to



improve the state in other ways; species such as top minnows, which are mass cultured to provide a plentiful supply of bait used for commercial purposes.

The Malaysian prawn (Macrobrachium rosenbergii) is the most successful aquaculture species cultured in Hawaii. The Department of Land and Natural Resources Division of Fish and Game instituted the most intensive research on prawns at the Anuenue Fisheries Research Center on Sand Island. In 1965 36 Malaysian prawns were brought back to Hawaii from Penang, Malaysia. By 1969, tests were begun in full-scale ponds. During the years, hatchery and grow out technology was perfected. Harvesting takes place after a seven month growing period. The fastest growing reach the size of five to seven prawns per pound. With these conditions, production can reach 2,500 to 3,500 pounds of prawns per acre per year.

"From 1972 to 1977, prawn production in Hawaii increased from 4,000 pounds a year to 51,000 pounds. Even with the rise in production, Hawaii still imports approximately 5,000 pounds of prawns each year."<sup>3</sup> Production was expected to increase another 120,000 pounds by next year.

"Prawns are considered a luxury food and are in such high demand that the wholesale price is approximately \$3.50 per pound. Local supermarkets have priced prawn tails at \$7.00 to \$8.00 per pound in comparison to lobster tails that retail for about \$9.00 per pound, and whole marine shrimp at about \$8.00 per pound."<sup>4</sup> In Hawaii, prawns are sold whole, live or fresh on ice. Restaurants serve prawns in a variety of ways. Many establishments allow customers to choose their own live prawns.

Some initial problems in establishing an aquaculture industry are determining the number of permits, project reports and public hearings that may be required for government approval. There is also the problem of uncertainty in



many laws and regulations concerning aquaculture. Many are broadly phrased and need administrative judgements for final decisions. Government approvals for aquaculture can vary greatly depending on the project's location, complexity, its potential impact and types of activities involved.

Although much is in favor of aquaculture, limiting factors must also be analyzed. There are always the possibilities of disease, predators and change in water quality and availability. Aquaculture must compete for land, labor and government support.

Aquaculture relates to state goals in many ways. Open space can be preserved because aquaculture utilizes low structures other than tall buildings. The utilization of lower quality land will not increase developmental pressures. The state will become more self-sufficient and will rely less on imports. The Neighbor Islands, that rely primarily on agriculture, will have a chance of diversification. Availability of employment will increase, agricultural lifestyle in Hawaii will be preserved, but at the same time continue to be updated. Resources that are readily available will be preserved and developed.

Future trends will have some type of impact on aquaculture. As the population increases, land, fresh water and specialized labor becomes scarcer. The rise of energy costs will affect aquaculture in many areas. Some of them include; pumping, which comprises a large percentage of production costs; the necessary equipment and supplies, which are sent from the mainland; and the transportation to deliver products to markets. In addition, competition will rise between local farmers and producers from foreign countries.

In order for aquaculture to become a major industry in Hawaii, state government must further encourage and assist in the study, farming and marketing of aquaculture. The benefits are so numerous and Hawaii's conditions are



ideal for such an industry. Seeing all of the benefits aquaculture holds for Hawaii, and the unstable conditions of agriculture, it seems almost foolish to continue aquaculture on a small-scale basis. Aquaculture will not only create new jobs for future generations but improve Hawaii's standard of living while maintaining its much loved life style.

#### FOOTNOTES

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THE ECONOMICS OF PRECIOUS CORAL  
by Marjorie de la Pena and Torrey A. Offley, Kapaa High School

INTRODUCTION

Deep in the Pacific Ocean, near the Hawaiian Islands, lie beds of precious coral. For years they lay undisturbed, until we on the surface found the beds, desired the coral, and divers sought to harvest it.

This is the story of the precious coral industry in Hawaii, but worldwide the picture is different. Japan and Italy dominate precious coral production. The world annual production at the retail level is \$200 million, and Hawaii's take is estimated at \$115 thousand. A look at these figures prompts us to ask,

"Why doesn't Hawaii develop its precious coral industry so that we can increase our share of the profit?"

As a matter of fact, the precious coral industry has already seen rapid growth in Hawaii. A steady rise in tourism and vigorous marketing efforts by those locally involved in the coral business have contributed to this end, as has a current state Sea Grant- and industry-supported research program at the University of Hawaii.

The purpose of this paper is to examine the economics of Hawaii's precious coral industry. We are looking for feasible methods of increasing Hawaii's contribution to the world's precious coral market while still protecting the resource itself.



## A LOOK AT THE CORALS

There are three types of coral which are considered precious, and thus commercially desirable. These are black, pink and gold coral.

Black coral, or Antipathes grandis, was the first to be utilized as a precious coral. In 1958, black coral beds were discovered off Lahaina, Maui, and the industry began. The harvest of black coral has increased periodically in Hawaii, with primary places of harvest being the Auau Channel off Maui and the southern shore of Kauai.

Black coral jewelry was created with the tourist in mind. The desirability of the jewelry lies in its exotic beauty, and of course, in its being a treasure from Hawaii's deep seas. Japanese tourists prefer black coral jewelry because pink coral jewelry is abundant in Japan.

The present price per pound for black coral is \$14.02.

Pink coral, or Corallium secundum, was discovered in Molokai Channel, six miles off Makapuu, Oahu, in 1966. In Hawaii, it can presently be found in a range which extends from the Big Island to Midway. Japan controls the Milwaukee Banks pink coral beds, which lie about 500 miles northwest of Midway.

Pink coral has been in use since pre-Christian times. Italy, Tibet, China, India, Persia and Japan have all valued pink coral commercially as well as for its supposed mystical power. Before 1830, most pink coral came from the Mediterranean Sea, but during the last century, Japan, Okinawa and Taiwan have become the major producers. Presently Hawaii produces about 75% of the pink coral sold in the islands, with the remainder being imported from Japan, Taiwan, Hong Kong, Okinawa, and Italy.



Of all precious corals, pink coral is the largest selling because of its abundance and its large range of colors, from almost white to orange-red. The most desirable shade in terms of sales is a very light pink called Angel's Skin, which makes up about 10% of the total pink coral harvested.

Pink coral is priced at an average of \$34.31 per pound, making it more expensive than black coral.

Gold coral was first discovered in 1967, although it was not used commercially until 1974, when large bed of gold coral was found off Kaena Point, Oahu.

Because of its rarity, gold coral is more expensive than either black or pink coral. The average price per pound is \$51.94, although actual prices range from \$48.75 to \$65.00 per pound.

#### A LOOK AT THE INDUSTRY

The harvest of precious coral, which grows at great depths, is accomplished by diving. Black coral grows at depths generally ranging from 30 to 80 meters. Pink coral's depth range is about 350 to 475 meters, although some colonies have been found at depths as shallow as 230 meters. The depth of the coral beds as well as the uncertainty of even finding the coral once the dive has been made, make the dives dangerous. Thus, there are only about ten or twelve known divers in Hawaii, plus an unknown number of occasional divers.

The number of days spent diving per month depends on weather conditions, and can vary considerably, anywhere from zero to thirty days. There is no regular diving season. During a dive, which usually lasts ten or twenty minutes, depending on depth, a diver may harvest one or two coral trees.



An average daily harvest is four pounds of coral, and based on this figure, a diver can make an average of \$56.08 per day diving for black coral, \$137.24 per day diving for pink coral, and \$207.76 per day diving for gold coral. However, there is no guarantee that a dive will be successful, and a day's work may yield nothing. On the other hand, the diver may find and harvest a bonanza of coral trees and make a great deal of money.

The primary characteristic of Hawaii's precious coral industry, harvesting included, is its uncertainty and instability.

#### THE FUTURE OF THE INDUSTRY

Because of the precious coral industry's instability, there is little potential for larger yields unless several developments are made. One possible means of expanding the industry is to find better means of harvesting the coral. But mass-harvest operations will exhaust known supplies of coral in a short time. Divers already believe that local beds will be exhausted in ten to twenty years, using present harvest methods.

A solution to this problem would be the development of a coral aquaculture system, similar to the system which is utilized to preserve evergreen forests. Because evergreens take so long to grow, new trees are planted each year in order to insure that there will always be trees ready to be harvested, with many remaining to reach maturity in successive years. Such a cultivation system would also preserve coral, which also has a lengthy growth span.

However, such coral aquaculture is unfeasible now because the depths at which the corals grow are difficult to reach and work at, and the other conditions needed for precious coral growth, such as proper temperature, salinity, and nutrients, are difficult to achieve and to maintain.



Therefore, harvest through diving is the only means of coral conservation that we have at this time. The difficulty of harvesting coral by this method protects the resource.

#### CONCLUSION

The precious coral industry in Hawaii needs further study. Our findings show that unless coral aquaculture is made feasible, there is little that can be done to expand the industry in Hawaii without exhausting our coral resources.

Perhaps the very term "precious coral" can shed some light on the industry itself. Like any precious gem, the rarity of precious coral is what makes it desirable. Pearls can be cultivated, but cultured pearls are not as valuable as natural pearls. The same principle may hold true for cultivated versus naturally grown precious coral.

To preserve our precious coral resource, while maintaining its rarity, a means of regulating coral harvest should be set up following a study of coral growth patterns and conditions. The discovery of new coral beds should be encouraged, although with the stipulation that the harvest of the new beds be regulated also.

Finally, precious coral beds in Hawaiian waters should be protected from harvest by foreign competitors.



Fig 1.

Amount of Black Coral Harvested.  
Every pound harvested is sold.

July 1977 - December 1977 669 lbs. for \$ 9394  
January 1978 - October 1978 476 lbs. for \$ 6671

Note instability of harvest.

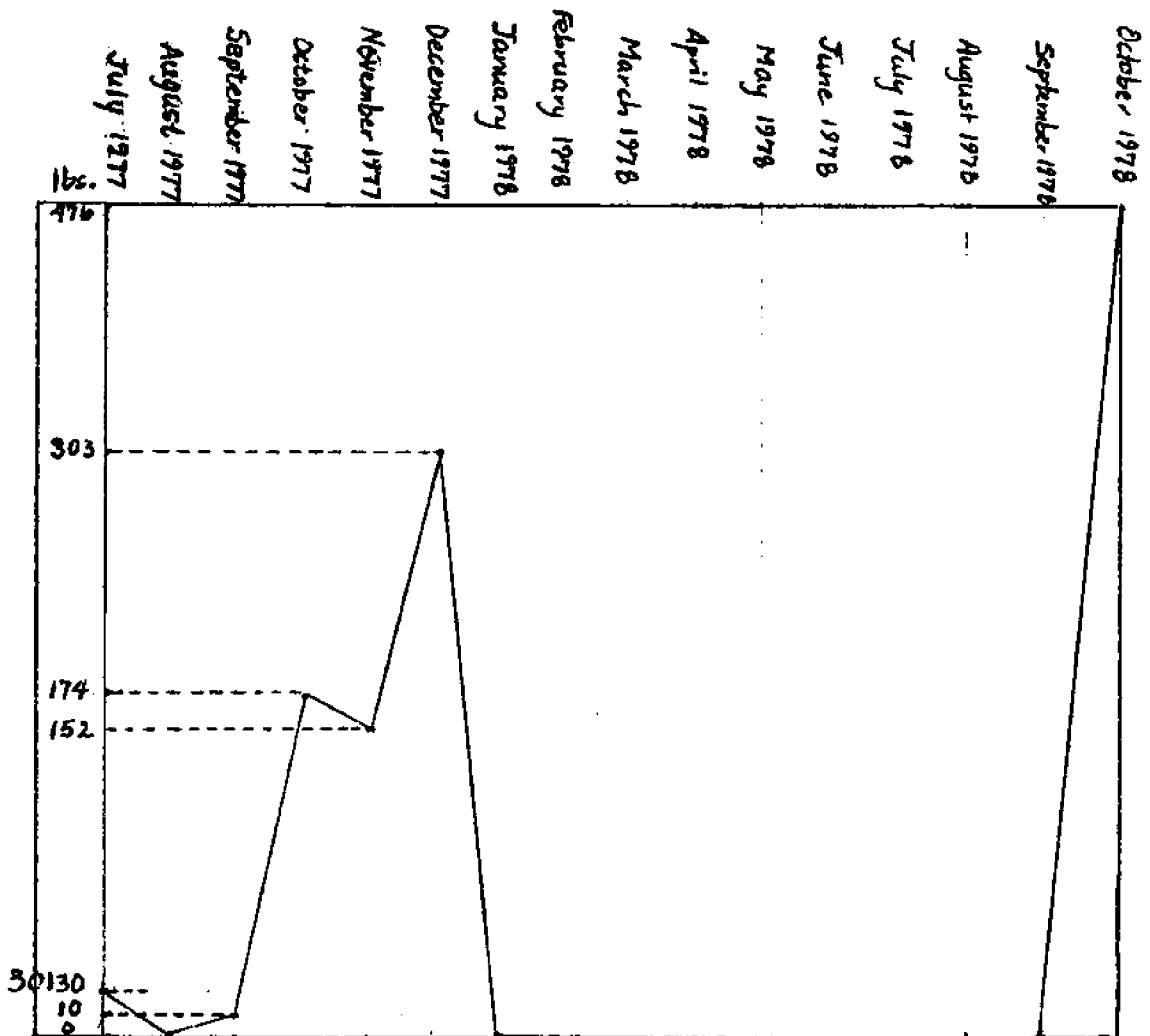




Fig 2.

Amount of Pink Coral Harvested  
Every pound harvested is sold

July 1977 - December 1977 1657 lbs. for \$55,826  
January 1978 - October 1978 1705 lbs. for \$59,565.50

Note instability of harvest.

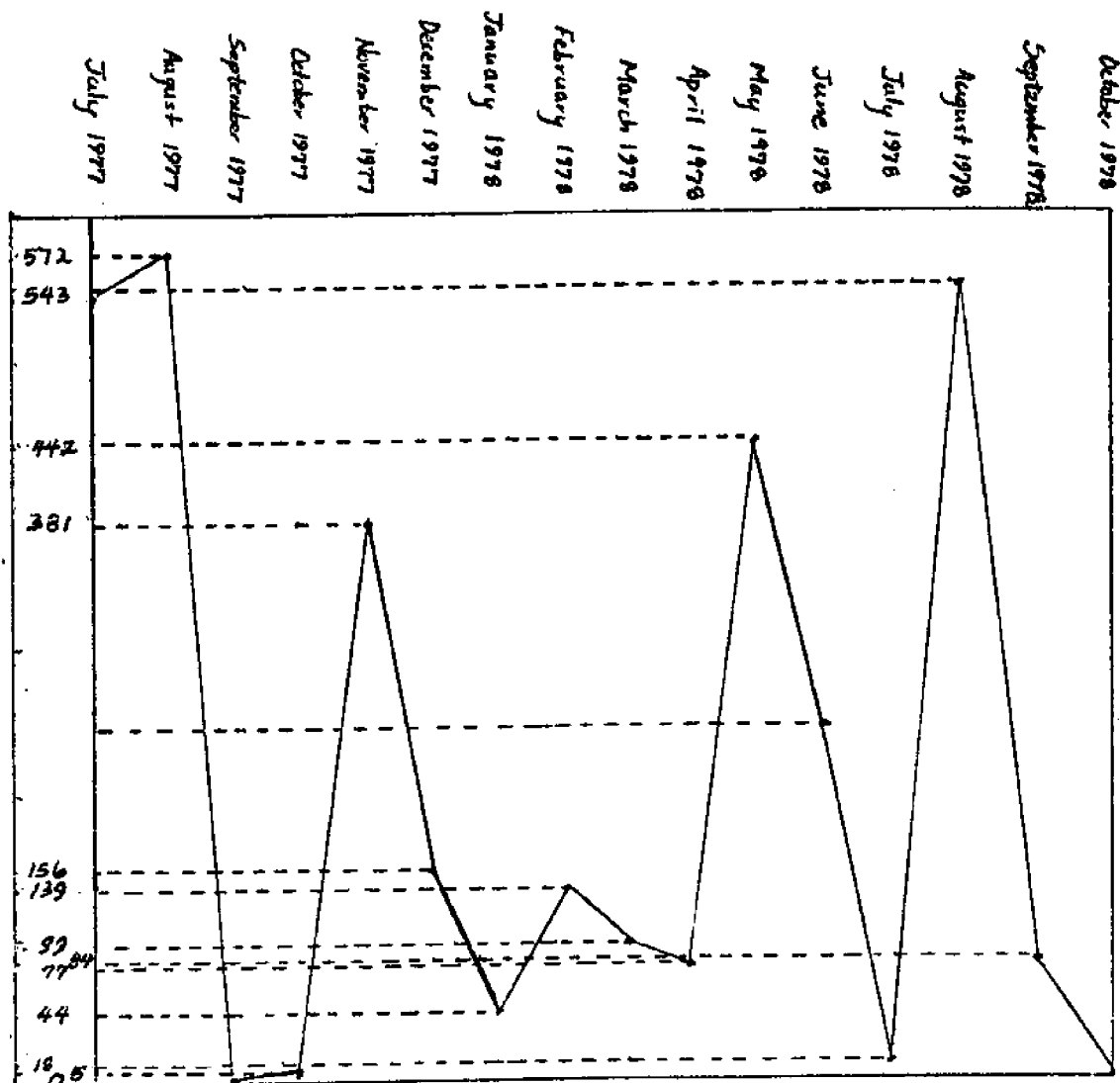




Fig 3.

Amount of Gold Coral Harvested.  
Every pound harvested is sold.

July 1977 - December 1977 329 lbs. for \$ 16,395  
January 1978 - October 1978 442 lbs. for \$ 22,095

Note instability of harvest.

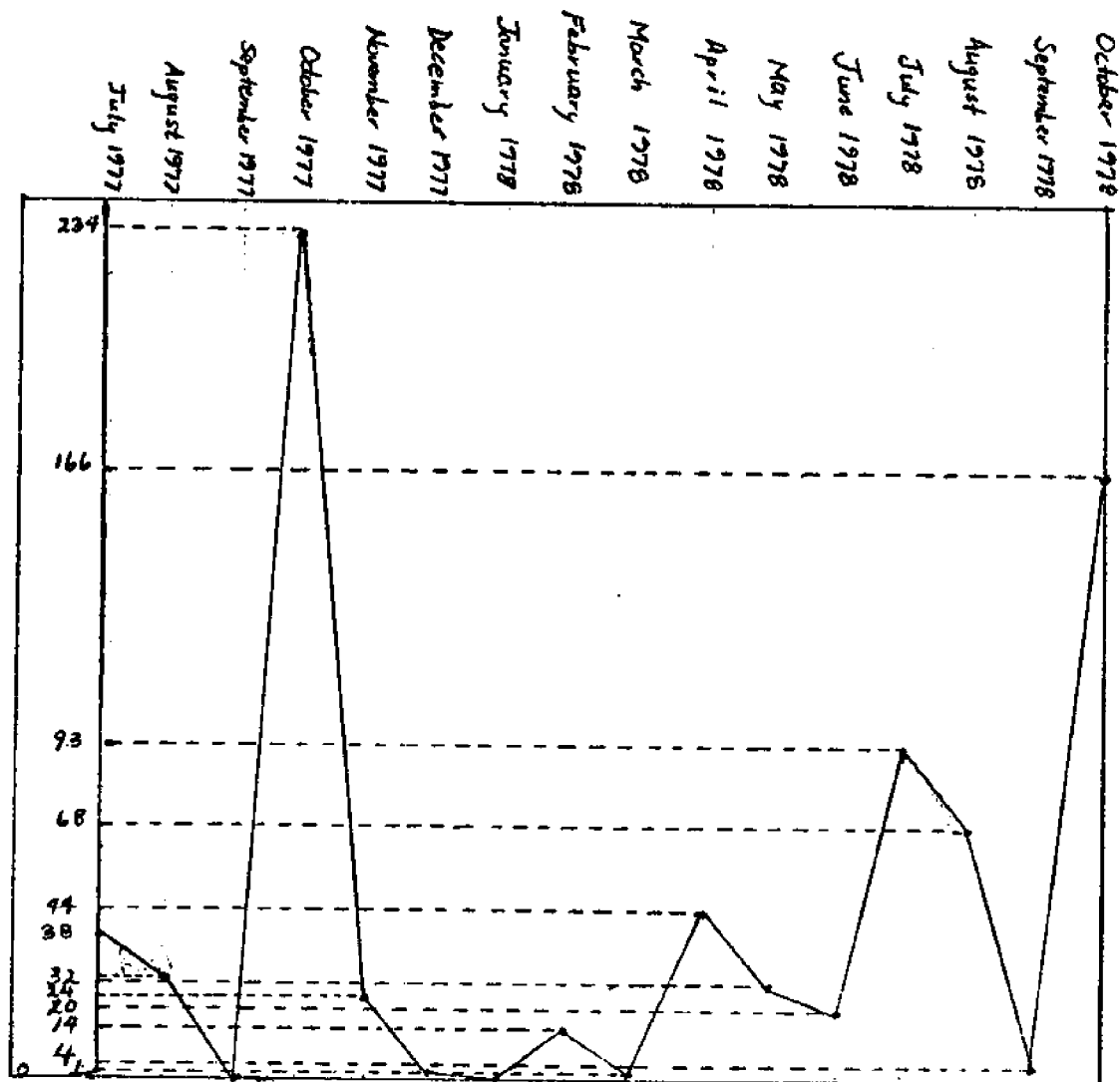




Fig 4.

Total pounds sold, value, and average cost per pound for Black, Pink, and Gold Coral. All precious coral harvested for commercial use in Hawaii is sold.

Month	Pounds Sold	Value	Average Cost per pound
July 1977	661	\$ 19,263	\$ 29.14
August 1977	604	21,562	35.69
September 1977	10	140	14.00
October 1977	413	14,237	34.47
November 1977	557	16,655	29.90
December 1977	460	9,758	21.21
January 1978	44	1,540	35.00
February 1978	153	5,537	36.19
March 1978	100	3,501	35.01
April 1978	121	4,870	40.25
May 1978	474	17,043	35.95
June 1978	263	9,450	35.93
July 1978	111	5,257	47.36
August 1978	627	22,965.50	36.63
September 1978	88	3,172.50	36.05
October 1978	642	14,996	23.35
Total	5328	\$ 169,947	\$ 31.90



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# Manganese Resources







THE OCCURRENCE AND DISTRIBUTION OF FERROMANGANESE NODULES  
by Ethel Sakoda, Pahoa High School

ABSTRACT

Distribution of manganese nodules in the world ocean is extremely important to the people of Hawaii. This is because Hawaii is the land closest to the largest accumulation of these manganese nodules. This industry may be ~~very important~~ important to those of us in the Puna district because a processing plant could be built.



## INTRODUCTION

One hundred years ago, the widespread occurrence of ferromanganese nodules and crusts on the ocean floor was discovered during the deep-sea expedition of the H.M.S. Challenger.

These nodules precipitated out of the water over great numbers of years. As the need to find new sources of minerals increases, the distribution and accessability of this resource becomes more and more important.

Ferromanganese nodules have seed grains that serve as a nuclei. In order for ferromanganese accretion to take place, it is imperative that a solid base, regardless of its size and composition, is available for initiation of the process.

There are two different types of nodules that have their own kind of nucleus. One type is the small nodules which are 1-4 cm. in diameter. These nodules have a smooth outer surface and well defined nuclei of yellow grains of palagonite. These small nodules result from the interaction between unstable basalt and seawater.

The second type has an irregular outer surface and a disc to subspherical shape. The nucleus is a large fragment of a former concretion. The fragments represent a period of degradation from an earlier period of nodule growth. Features of the nuclei of the earlier period of nuclei development have been erased by total replacement. This is why it is necessary to use the smaller nodules with their well-preserved nuclei as a means of understanding the controls of distribution.

There are two dominant types of ferromanganese deposits each reflecting conditions at the site of deposition. Encrusting material develops on exposed submarine elevations where current activity prevents normal sediment accumulation. This current provides a continuous supply of metals which



accrete to exposed surfaces and form ferromanganese crusts.

The second type is nodular and forms at great depths where sediment accumulation is negligible. In these deep abyssal areas, ferromanganese precipitates about nuclei (volcanic, biologic, glacial, nodule fragment, etc.) and in time the addition of concentric layers results in the formation of nodules.

The distribution of ferromanganese deposits in the North Atlantic is restricted. They have found only scattered occurrences.

Ferromanganese deposits of the South Atlantic and western Indian Oceans are restricted to areas of either non-deposition or negligible sediment accumulation. Ferromanganese is more widespread in the South Atlantic than in the North Atlantic.

The North Pacific Ocean is the largest sedimentary basin in the world. It receives very little land-derived sediments. Their distribution is a function of low rate deposition of red clay (less than 1-3 mm/1000 yr.), and ooze (3.5 mm/1000 yr.). The North Pacific has the highest density of nodular deposits in the world ocean.

The South Pacific is similar to the North Pacific. However, fewer samples of ferromanganese have been recovered and less is known about the sediments of the region.

1. D. R. Horn, B. M. Horn and M. N. Delach

Factors Which Control The Distribution Of Ferromanganese Nodules

2. David R. Horn

Ferromanganese Deposits On The Ocean Floor



**MANGANESE NODULES AND THEIR POTENTIAL IN HAWAII**  
by Randall Bachman, Waiakea High School

Physical Characteristics

Manganese and iron peroxides are distributed on the ocean floor as grains, nodules, slabs and coating on rocks. Small manganese dioxide grains about 0.5 mm. in diameter are almost the same as red clay and organic ooze found in the pelagic areas of world oceans. Frequently rock outcrops are coated with a layer of manganese and iron oxides sometimes 10-15 cm. in thickness. Big rocks, boulders or rock slabs that were carried out by icebergs or seaweed are commonly coated with manganese oxides.

Manganese nodules have been found in a variety of physical forms. Agglomerating colloidal particles tend to form a spherically-shaped concretion. The nodules have been described as appearing like potatoes, marbles and tablets.

Manganese nodules from the sea floor are generally earthy black in color; however, the color may vary from black to tan. Nodules with a high iron content are generally reddish brown while nodules with a high manganese content are blue black in color. The hardness of the nodule is variable ranging from one to about four on the Mohs scale. In size the manganese nodules range between 0.5-25 cm. in diameter. The biggest nodule ever found and kept was dredged from the



Blake plateau off the east coast of the United States--it weighed 55 kgs.

#### Formation of Manganese Nodules

There are several ways in which manganese is added to the sea. They are: streams; submarine volcanic eruptions; springs; and the decomposition of sea floor igneous outcrops and debris. It is agreed by oceanographers that the dissolution of igneous rocks both on land and on the sea floor, is the major source of the manganese and iron in the ocean. Another theory is that carbonate and sulphate bearing waters act on the sea floor rocks to release manganese, mainly as the bicarbonate. Since there is dissolved oxygen in the sea, the bicarbonate may be transformed to a colloidal manganese peroxide which collects on any convenient hard surface to which it attaches. This theory was a common geochemical cycle of manganese on the continents.

#### Mining of Manganese Nodules

There are many different methods of mining sea floor surface sediments. There are unmanned crawler-type units which submerge, fill with manganese nodules and surface; there are manned crawler type bathyscaphs which serve as the motor power to pull scraper units along the bottom; and a large submarine with manned spherical control chambers and flooded storage chambers into which the nodules are gathered.



For the immediate future the only two methods of bringing the nodules to the surface are the deep sea drag dredge and the deep sea hydraulic dredge. Probably the best method of mining sea floor nodules is some form of deep sea drag dredge. The type of equipment involved is simple, inexpensive and has been used for about a hundred years to recover sediments at depths of over 30,000 feet deep.

#### Manganese Nodules a Mineral Resource

Since manganese nodules are full of minerals it would be a good mineral resource, but it is yet to be seen. Undoubtedly, it would be very profitable to mine certain of these deposits, even at present day cost. Laboratory experiments indicate that there should be no major problems in adapting existing industrial equipment and processes to the mining and processing of the manganese nodules. Studies have shown in the past two years that the nodules should be composed of manganese, nickel, cobalt and copper. Other materials such as molybdenum, lead, zinc, zirconium, several of the rare earth elements and possibly iron, aluminum, titanium, magnesium, and vanadium could be recovered as by-products.

#### Manganese Mining and Processing

Hawaii may soon be benefiting economically from the mining of the vast quantities of metal-enriched manganese nodules which have a large amount of all kinds of metals and



which are found at the bottom of the Pacific Ocean floor.

Now in Hawaii people have been working on developing and testing technology and different types of machines to collect the metal-enriched manganese nodules at the ocean floor. There will be more employment available in Hawaii because of providing goods and services to ships and crew that will be mining the nodules near Hawaii. However, the greatest economic benefit would derive from a large processing plant in Hawaii.

Hawaii's locational advantages for attracting such a plant possibly on the Big Island include:

1. Proximity to the richest concentration of manganese nodules.
2. Abundant water supply.
3. Port facilities.
4. Energy supplies from oil shipped from Alaska, bagasse, and eventually geothermal power.
5. Central location between American and Asian markets.

#### Hawaii Up to Now

Hawaii at present has played only an indirect, limited role in the potential development of a marine mining industry. Honolulu and other parts in the Hawaiian islands have furnished ships for exploration.



### Nodule Waste Transportation in Hilo in the Future

Manganese nodules will be mined and then will be transported in barges to Hilo harbor and then pumped in slurry form through a pipeline from the port facilities to the processing plant. Processing wastes will be pumped through a pipeline to the port facilities and onto barges preparing to return to the mine site. These activities are not likely to have a significant impact on the environment except in the case of accidents. Pumping of process wastes, or improper storage of them on land, could have significant impact. At the port at Hilo, special facilities would be required to receive nodule shipments. A special unloading pier will have to be built with three ponds: one to take the nodules, one to take the trace nodules; and one for water which will also be needed. Then the nodules will be transported eight to nine kilometers to the Puna District near Keaau. It is assumed that the reduction ammonia leach process will be used to extract nickel, copper and cobalt from the nodules. Most of the chemicals needed for processing nodules will be imported from the mainland. The wastes from the processing will perhaps go back to the port and back on the ship and be taken back to the mining sight. Metals recovered by the processing will be shipped to the mainland or other metal fabricating plants.



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MINING THE OCEAN FLOOR  
by Cindy Aoki, Waiakea High School

Manganese nodules are black, pea to potato sized and shaped. They are authigenic deposits composed chiefly of metal oxides. Manganese nodules are formed when manganese and iron oxides from land form an accumulation on other deep sea sediments and continue to grow as coat after coat is added. These nodules are found in abundance on the ocean floor. Hawaii is near a belt of high grade manganese nodule deposits that is located just off the coast of Central America at a point southwest of Hawaii. Because these nodules contain quantities of iron, nickel, copper and colbalt, there are several proposals for obtaining them and using them for mineral resources. Present indications show that the first commercial recovery of nodules for extraction of nickel, copper, colbalt and possibly manganese will begin in the mid 80's.

Different consortia favor different processing techniques, which prove that more than one technique is economically feasible.

One of the nodule collection devices to be used in Hawaii is that of the Deep Sea Miner II. This consortium is led by Deep Sea Ventures. The Deep Sea Miner II is a 20,000 ton, 560 ft. converted ore carrier. Its 70 ft. high, 52 ft. diameter geodesic dome provides a weather cover for a 55 ft. high gimbal mounted derrick which can support up to one million pounds of dredge pipe. A dredge head is lowered over the side of the ship and keel-hauled under a 27 ft. wide by 34 ft. long moon pool. The pipes are pulled up through the moon pool, a large rectangular vertical hole through the center of the ship.



The SEDCO 445 of the INCO consortium has air lift pumps which inject air into a 9.625 in. diameter pipe string at depths from 5,000 - 8,000 ft. Submersible hydraulic pumps are installed in the pipe string at a depth of about 3,000 ft. A nodule collector head 40 ft. wide can collect up to 250 tons of nodules per hour, during full scale operations.

These are just a few of the techniques used. There are many others who have also been collecting and testing.

A manganese nodule processing plant in Hawaii would have various effects. An economic impact is expected on the state and county. Although millions of dollars would be needed to build and maintain such a plant, it would also create many new jobs. New laborers will be needed for construction of the plant and machinery. After the plant is established, workers will be needed to man the processing plant, the nodule ships, and for ocean, land and air transportation. This creation of new jobs would cause a personal income increase. A nodule processing facility can also be expected to generate sizeable federal, state and county tax revenues.

The mining of manganese nodules will have a definite effect on the environment. Sea floor mining operations will disturb the bottom sediments and other various sea organisms, therefore throwing the balance of nature off. Processing wastes will be returned to the mine sites. This dumping of wastes or the improper storage of them on land could have a significant impact on our environment.



The amount of manganese found on land is limited, because of this it is an important potential economic resource. Manganese nodules will be processed for their nickel, copper and cobalt content and possibly for manganese, molybdenum and other metals as well. The United States is almost completely dependent on foreign supply of nickel, cobalt and manganese. Nodule mining and processing could reduce this dependency considerably.

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POSSIBLE METHODS AND PROBLEMS OF MANGANESE NODULE MINING  
by Kevin Jackson, Waiakea High School

INTRODUCTION

Today the United States imports vast amounts of resources from overseas to meet the demands of it's growing industry. Some of these resources we depend upon to run our factories, provide electricity for our homes, and make steel and other metals which are vital to our economy. With improved mining technology some of these vital minerals can be gathered in vast quantities, reducing or even stopping our dependence on foreign countries. Manganese nodules are part of the answer because they are abundant and contain vast amounts of minerals.



## HYDRAULIC DREDGE SYSTEM

Manganese nodule mining requires specialized equipment because it usually takes place in waters which are between 15,000 to 18,000 feet deep. Currently there are two methods under investigation which are capable of mining nodules at such extreme depths. Of the two possible systems the hydraulic dredge system is favored because it has a greater commercial potential.

Basically the hydraulic dredge is like a huge vacuum cleaner which picks up nodules by suction. It looks rather like a large sled which is connected to the mining ship by 18,000 feet of pipeline. When in operation the dredge is slowly towed behind the mining ship by its 18,000 feet of pipe. As the dredge is towed, a powerful pump sucks up the nodules and transports them through the pipeline to the mining ship above. To prevent clogging of the dredge, it has a screening device which will shuttle aside nodules too large for the pipeline.

Through clever engineering several potential mechanical problems were solved.

The first problem is how to get the nodules from the dredge and through the pipeline, to the mining ship, which could be floating as much as 18,000 feet above the dredge. There were two possible solutions to solve this problem.



One solution employed the use of submersible pumps to draw water and nodules up through the pipeline. The second solution used compressed air injected to several points along the pipeline which rises and expands to provide a lifting force.

Another problem was concerned with the stress and strain on the pipeline. To solve this problem, special joints were used to create a string of pipeline strong enough to withstand the stress of its own weight and the stress of the dredge being towed along the bottom.

Finally a specialized hydraulic mast and transfer system was invented, which was capable of handling the 18,000 feet of pipe line, it also pivots freely to keep the mast at a vertical position regardless of the ship's pitching during rough seas.

To aide in the location of manganese nodules, each dredge will be equipped with T.V. cameras and flood lights to allow the controlers to scan the ocean floor.

#### Bucket scoop system

The other system is the bucket scoop system which is not as favored as the hydraulic system but still has commercial potential.

When mining with the bucket scoop system, the buckets on a long loop of cable strung between 2 ships will scrape the bottom, emptying the contents on one of the ships, then rotate to the other ship where they return to the bottom in a continuous rotating cycle.



The main advantage of the bucket bridge system over the dredge system, is that it can scrape nodules up along a wide path.

#### Potential of manganese mining

The potential of manganese mining has a very promising future with 15 to 20 mining sites in operation by the year 2010. The Department of interior estimates that there are 180-460 commercially viable first generation mine sites which are available. What makes manganese nodules a reality in the near future is the United States shortage of certain minerals which are abundant in the nodules, such as nickel, cobalt, manganese, and copper. Right now the U.S. imports 71 percent of it's nickel, 98 percent of it's cobalt and manganese, and 15 percent of it's copper.

The proposed processing plant on Hawaii will be a large operation capable of handling 3 million tons of manganese nodules per year. The mining of the manganese nodules will take place about 1,000 miles south of Hawaii, in a nodule field which has manganese nodules high in mineral content. After the nodules are mined they will be transported to the port of Hilo using a tug and barge system. When they arrive at Hilo, the nodules will be pumped in slurry form, through a pipeline to a processing plant about 8 to 10 miles south from Hilo in the Puna district.



The processing plant will probably recover nickle, copper, and cobalt; then despose of the waste by pumping it through a pipeline back to Hilo, where it will be loaded on barges, and dumped some time during the barge's return to the mine site.

#### Possible Environmental Problems Of Nodule Mining

With these good aspects of nodule mining there are also some bad ones, such as environmental problems that could arise from mining oprations. At present marine biolgists don't know very much about ocean bottom organisms which could be hurt by the mining dredges tearing up the sea bottom. To prevent these possible enveronmental problems the National Oceanic Atmospheric Administration have scientists studying the bottom organisms to determine how much and what kind of damage nodule mining will do.

One Potential environmental problem which could arise from nodule mining is the seafloor may be scraped as deep as 2 inches, violently displacing organisms accustomed to a life of little change. Another problem which might arise is the stirring up of sediments, which could bury bottom organisms upon resettling. In recent months scientists have identifed over 20 nodule dwelling organisms which live in the pore spaces of the nodules. If mining becomes a large scale operation all the organisms living on the nodules picked up by the dredge will be destroyed.



### Possible Environmental Problems of Waste Disposal

The dumping of waste and ocean bottom sediments as a result of manganese nodule mining operations could be harmful to the marine environment. Waste dumped from the surface into the photic region will block out some sun light, which will interfere with photosynthesis. Perhaps this will be offset by the introduction of nutrients from the deep, increasing productivity.

The most serious environmental problem that could arise from dumping might be the eutrophication of the upper waters of the ocean, as has occurred in Lake Erie and countless other bodies of water.

### SUMMARY

In the near future manganese nodule mining will become a large industry which will supply the world with much needed minerals. There is a possibility that other forms of ocean mining will come into reality such as extracting minerals from sea water and the development of aquaculture. However, with all the industrial potential that the ocean can provide, we must not overlook the environmental problems which could arise. The sea can be a great benefactor to mankind if used wisely, but if mistreated it will provide us with very little.



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# Marine Mammals







COMMUNICATION OF AQUATIC MAMMALS IN THE ANIMAL WORLD  
by Allison Fujimori, Ka'u High School

Introduction

"Among dolphins an individual creates a game, others perfect it, and several play it. We have here intelligent creation, teamwork, and a capacity for attention which are very rare in the animal world."<sup>1</sup> Man has known for some time that dolphins are able to learn to perform many difficult tricks. However, only now are they understanding these animals have remarkable methods of communication. If this is so, what about other aquatic mammals, such as the walrus, horn-honking trained seals (as the California sea lions are erroneously called) and whales? Animal-film director Ivan Tors spent many nights with the white whale Namu and reported that the five-ton mammal was "the most intelligent creature I ever met."<sup>2</sup>

Pinnipeds, which include the true (or earless) seals, sea lions, other eared seals, and walrus', and cetaceans, which include the whales, porpoises and dolphins, are mammals living near or entirely in water. Aquatic mammals are descended from land mammals. They developed over millions of years special physiological adaptations for life at sea. For example, the flippers of present day seals gradually replaced the feet and legs of their ancestors. This modification of limbs hampers pinnipeds, or "fin-footed ones," on land but helps them to move more swiftly in water. Aquatic mammals have larger, longer lungs than terrestrial mammals. When the water-dwellers submerge, special muscles or valves contract to slow the flow of blood to the extremities, while allowing it to flow freely to

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<sup>1</sup>Robert Merle, The Day of the Dolphin, p. 17.

<sup>2</sup>William F. Evans, Communication in the Animal World, p. 119.



the heart and brain. The ears and nose also close when under water.

This paper will cover the various methods of aquatic mammal communication—visual signals, olfactory and tactile signals and auditory signals. Dolphin "sonar" and the question that has interested man for centuries, "Can we talk to dolphins?," will also be discussed.

### Results of Research

Marine mammals do not have particularly good eyesight, although it is thought to be better developed in the pinnipeds than cetaceans. Occasionally, a sperm whale will lift his head to look about, and the bottle-nosed dolphin can see moving objects in air at about forty feet. Because their eyes are placed laterally—on the sides rather than front, cetaceans lack depth perception and stereoscopic sight. Their eyesight is further limited by the fact that ocean water is not highly transparent. The small eyes of whales, porpoises and dolphins can withstand extreme pressure when the animals descend to greater depths. They are equipped with special tear glands, which produce an oily substance for protection against irritation by salt water.<sup>3</sup>

Because of their limited eyesight, it is not surprising that aquatic mammals do not communicate through visual signals to any marked degree. The hooded seal of both sexes has an inflatable hood or pouch of muscle tissue (larger in the male), which extends from the nose to the top of the head. When angered or aroused, the seal inflates the pouch, which turns a brilliant red and lets out a roar that can be heard miles away. This audio-visual display is effective in frightening away potential enemies. Aside from displays involving territorial defense and mating, little is known about the visual signals of aquatic mammals.<sup>4</sup>

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<sup>3</sup>J. H. Prince, Languages of the Animal World, p. 132.

<sup>4</sup>Ibid., p. 64.



Seals and walrus are more gregarious than the land carnivores they were formerly grouped with. Few species are solitary, and the majority (notably the eared seals) live in colonies called rookeries, whose populations range from one hundred to one million. Possibly, mutual identification of parents and young are aided by the sense of smell. Although not especially well developed in pinnipeds, the sense of smell is utilized by all young mammals to a greater extent than the visual sense.

Whales and dolphins have little or no sense of smell. Their olfactory nerves are dead; olfactory bulbs—well developed in mammals with a keen sense of smell—are nonexistent in these animals. Although they have lungs and breathe like other mammals, cetaceans cannot live on dry land. Air breathing nostrils open externally through a blowhole (single in toothed whales, dolphins and porpoises and double in baleen whales) and are usually located on the highest point of the head. The lungs are connected directly to the blowhole, not to the mouth as in other mammals. Breathing is synchronized with surfacing. The blowhole automatically closes when the animal submerges.

Cetaceans have a keen sense of taste. They locate fish by means of sound and decide whether to eat it by tasting the water nearby first.

Tactile organs on the skin of aquatic mammals are numerous, and their sense of touch well developed. For example, the walrus and earless seals use their snout vibrissae, or whiskers, to locate food along the muddy floors of turbid water where they live. The sense of touch is important in the care of the young and courtship. The mother walrus defends and guards her young by carrying the calf on her neck even when swimming and diving. A courting pair of Falkland sea lions will climb ashore, sit facing each other and caress each other by twisting their necks from side to side like snakes. The female may even occasionally nibble the male's neck.

In the beginning, dolphin courtship is gentle. The male displays himself to



his lady friend, and a certain amount of nuzzling takes place, accompanied by high whining sounds. Finally, the male becomes impatient and speeds toward the female head on. The female races away and is pursued by the male. Both make great leaps out of the water, vocalizing loudly as they do.

Similarly, a pair of humpbacks will swim side by side exchanging blows. Like dolphins, they may throw themselves out of the water landing in a tremendous splash.

Like other mammals, marine mammals have internal ear structures with three bones in the middle ear. The auditory nerve connects the hearing apparatus to the brain, permitting sounds to be interpreted by the animal and allowing scientific brain-mapping experiments to take place. This has been performed with much success in the case of the dolphin. The brain-mapping procedure consists of having the animal anesthetized. The cerebral cortex is then stimulated by passing small electrodes into the brain at various points and applying a weak electrical stimulus. The dolphin is watched closely for response, including vocalizations. The brain area is concerned with hearing, vision, tactile sensation, body movements, and emotional response. If applied in certain areas of the brain, strong stimulus causes dolphins to emit distress calls. It may be necessary to increase stimulus in an area to elicit response.

Eared seals are noisy, while earless seals are quiet. During the mating period, cows and pups in a colony of eared seals may be heard howling and bleating. The loudest barks and roars, however, are those of the fully mature males. Within a rookery of eared seals there is almost constant uproar caused by these sounds. An occasional squall of a pup separated from its mother may be heard also.

In spring, eared bulls stake out territories in areas where they expect to breed. They declare their intention to defend the territories with loud roars. These animals are polygamous, gathering harems of cows ranging in numbers of ten to fifteen in the case of Steller's sea lion, and up to a hundred in the case of



northern fur seal. The northern fur seal guards his harem jealously day and night, never leaving the territory long enough to seek food. He bellows defiantly to protect both the females and territory. He does not trust cows or neighbors and will sometimes fight with other bulls.<sup>5</sup>

Sea lion bulls, on the other hand, are more tolerant. The young male will bellow and roar although he has no harem to defend. He appears to be preparing for the end of his bachelorhood and when he can command his own territory. Female sea lions also vocalize, although their calls are of a higher pitch and lower intensity than those of the males. The calls of female sea lions are associated with mating and the care of young.

True seal sounds include low growls, snorting and blowing. These animals are promiscuous in their mating habits, although they do not congregate in large rookeries or harems. For example, the gray sea lion bull will fight for territorial rights but not for cows. Seals defend themselves by advancing toward intruders with their mouths open and uttering menacing cries or fleeing to water and diving in. At the end of the mating season, mature bulls will pull themselves on rocks to bask in the sunshine and bicker over favorite spots.

Young seals do not swim automatically; they must be taught. The Weddell seal mother, for example, employs the common, "Come on in, the water's fine," routine.<sup>6</sup> Fourteen days after the pup's birth, the mother coaxes it to join her in the water. She plunges in and scrapes a ramp for the pup to slide safely into the water.

Several species of aquatic mammals demonstrate remarkable homing and direction-finding abilities. The harp seal lives in Arctic waters and reproduces in only three locations within its range--the White Sea, western North Atlantic and an

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<sup>5</sup>Ibid., p. 65.

<sup>6</sup>William F. Evans, Communication in the Animal World, p. 125.



area near Newfoundland. The seal migrates singly or in small groups to breeding places in the fall, then returns to northerly latitudes in the summer. The northern fur seal travels to breeding rookeries at a distance of almost nine thousand miles per year. The California gray whale navigates six thousand miles mostly in the open sea. This yearly migration is from the Arctic Ocean and Bering Sea to the California coast and back.<sup>7</sup>

Little is known of the communication of migrating mammals except for the short barks given by true seals to keep group members within certain areas. Professor E. J. Slipper, author of the book Whales, states that schools of cetaceans are kept intact by the use of sounds as a means of communication. After being scattered by whale hunters, whales may reassemble by the use of sound signals to each other. The mysterious mass suicides committed by whales--as much as a hundred beaching themselves on shore--may use similar signals.<sup>8</sup>

In Antarctica a few years ago, thousands of killer whales arrived at a fishing ground but were driven away by a single fisherman's quarry. One ship radioed a fleet of whaling vessels, and several whalers arrived. Only one shot was fired from a single harpoon gun. However, minutes later, not one whale could be seen in the fifty-square-mile area covered by whaling ships, and none returned. The one whale hit apparently sounded distress or alarm calls, and the information of danger lurking on the surface of the sea spread quickly.<sup>9</sup>

The entire life of the whale is bound with the ability to perceive and produce sounds. They hear sounds of the crustaceans they feed on and their fellow whales crying out in distress. Echo location--bouncing sounds off submerged objects to determine shape, size and distance--is used for securing food. Many

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<sup>7</sup>Flora Davis, Eloquent Animals: A Study in Animal Communication, p. 142.

<sup>8</sup>Evans, op. cit., p. 125.

<sup>9</sup>Davis, op. cit., p. 143.



naturalists and fishermen have reported hearing whistles and squeals also.

William E. Schevill and William A. Watkins of Woodshole, Massachusetts, recorded underwater cetacean sounds. They showed that animals use vocal sounds to convey definite meanings. Of the many sounds recorded, many of them were done with the knowledge of the circumstances under which they were made. Also known was their interpretive significance. These studies were made with hydrophones. The utilization of many sounds probably depends on echo location in locating and securing food and also for communication between individuals. The sperm whale produces numerous sounds, including a series of clicks, grating groans of a low pitch, rusty hinge creaking, and muffled noises.<sup>10</sup>

Sounds of the white whale or beluga (a member of a dolphin-porpoise sub-family) were recorded by Schevill and Barbara Lawrence in the lower Saguenay River in Quebec. They found that the animal richly deserved the title "sea canary" because of its varied vocabulary consisting of ticking and clucking sounds, news, chirps, resonating high-pitched whistles and squeals, bell-like sounds, and low trills. These sounds are generally too high for human ears to detect unaided. However, white whales occasionally emit sounds resembling a group of children shouting at a distance. These sounds are most likely produced by a stream of air bubbles from the blowhole rather than the voicebox.<sup>11</sup>

Man has known for some time that dolphins are able to produce sounds and are affected by them. Aristotle claimed dolphins squeaked and moaned in air when captured, and other dolphins swam away quickly from these noises. Strangely, he believed they had no acoustic passageway.<sup>12</sup>

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<sup>10</sup>Esse Forrester O'Brien, Dolphins--Sea People, p. 70.

<sup>11</sup>Flora Davis, Eloquent Animals: A Study in Animal Communication, p. 154.

<sup>12</sup>Bill Gilbert, How Animals Communicate, p. 138.



Dolphins and porpoises are so closely related that their names are used interchangeably. The term "porpoise" is correctly applied to the round-headed mammals without beaks and laterally compressed teeth. Dolphins have beaks and spike-like teeth. Both are highly intelligent and favorites at various marineland throughout the United States. They have been taught to retrieve sticks, jump through loops and perform a variety of tricks.

Most of what we know of dolphin communication comes from studies of the playful bottle-nosed dolphin (Tursiops truncatus) that weighs about three hundred pounds. Its brain weighs about three-and-a-half pounds--the largest brain for its size of all mammals except man. The brain is deeply furrowed, convoluted and highly developed. Some experts rank the intelligence of the dolphin between that of the dog and chimpanzee, and others say it even outranks the chimpanzee.<sup>13</sup>

In 1953, W. G. Wood, curator at Marineland at St. Augustine, Florida, identified six sounds dolphins use to communicate with each other and for other purposes. The jaw clap, a flat, abrupt noise that resembles clapping, indicates a threat or warning and is used by the eldest male in the group. The short, flat whistle, followed by a high-pitched musical one, is a distress call. Dolphins within hearing range will respond to this call. A mother dolphin whistles to her baby, and the baby whistles back. The barking sound represents a warning or anger. This sound was recorded from an animal being pursued by a shark. Adult males emit yelping like a puppy's. This may be a mating call. Mewing and rasping may be heard while the animals are feeding. The "rusty hinge" sound is a dolphin's "sonar." This may be produced by rapidly pulsating clicks, which range from approximately half a dozen to several hundred per second. Because of this high rate, the sounds may be heard by humans only with special equipment.<sup>14</sup>

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<sup>13</sup>Esse Forrester O'Brien, Dolphins--Sea People, p. 138.

<sup>14</sup>Vitus B. Droscher, The Mysterious Senses of Animals, p. 19.



Other vocal sounds by dolphins include chirps, grunts, squawks, and sounds resembling the human voice. Only dolphins associated with humans produce loud singing sounds heard at oceanariums. Captive animals are more likely to produce sounds above water than free-ranging ones. Dr. John C. Lilly, the neurophysiologist, studied the dolphin brain. He was impressed by the sounds produced and was determined to learn their meaning. In 1955, he built a laboratory for this purpose in the Virgin Islands. While testing a dolphin in a tank, he called to his assistant "three-two-three," and the dolphin unmistakably imitated, "three-two-three."<sup>15</sup>

Dolphins have no vocal chords, and scientists have had problems determining their method of sound production until recently. Lately, research conducted demonstrated that deep inside the blowhole in the nasal passage, two flaps or tonguelike projections overlap. Air through the nasal passage causes the flaps to flutter, producing noise. Variations in pitch are caused by increasing or decreasing pressure on the flaps. Besides the flaps, also in the blowhole is a moveable "tongue" or "plug" that aids in the production of sound.

The frequency range of dolphin noise vibrations are three thousand to two hundred thousand per second. Noises resulting from the high-frequency vibrations include putting and creaking sounds. Whistling noises are often heard in the vocalizations of dolphins. They are of a fairly low range of six thousand to sixteen thousand cycles per second, each whistle lasting one-half second.<sup>16</sup>

William Schevill and Barbara Lawrence carried out a series of experiments with a dolphin on Nonomesset Island, Massachusetts in 1958. They discovered the dolphin could hear ultrasonic sounds in a far range and could perceive objects by means of reflected sound. They also demonstrated the dolphin uses the "rusty hinge" sound as an echo locating or sonar device.<sup>17</sup>

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<sup>15</sup>Bill Gilbert, How Animals Communicate, p. 154.

<sup>16</sup>Esse Forrester O'Brien, Dolphins--Sea People, p. 70.

<sup>17</sup>Vitus B. Droscher, The Mysterious Senses of Animals, p. 19.



Recorded sounds of dolphins (recordings slowed down for analysis) contain pings and resulting echoing pings clearly audible and visible on the oscilloscope screen. Captive dolphins accept fish only after transmitting sounds to fish and use echo location to find food. Tone varies with rate and is often emitted slowly enough to be heard separately. A tonelike effect results if the rate is increased to about two dozen or more per second. Sounds resembling groaning, mewing or moaning result if the rate is stepped up to over one hundred per second.

By bouncing sound off underwater objects, the dolphin determines the shape of the target or obstruction, direction and distance to it. For example, by using this method a fish is distinguished from a rock. The "rusty hinge" sound is the audible part of the sonar sound or series. Arthur McBride, first curator at Marineland at St. Augustine, discovered that bottle-nosed dolphins frequently swim around or jump over a fine mesh net. They avoid being caught in a net with a mesh size of ten inches or more. A fine mesh net probably appears to be a solid barrier because density reflects sounds, although some species of porpoises and river dolphins can avoid any mesh size.<sup>18</sup>

If a dolphin tank was purposely made turbid and fish were thrown in, a dolphin could still locate the fish. If it were blindfolded with suction cups placed over its eyes, the dolphin could still locate the fish, swim around without difficulty and surface with the prize in its mouth. Using the sonar in the same way, the animal navigates across muddy waters of docks and piers.

Whales and members of the dolphin family "see" objects through water by sending out messages, and both possess a rich vocabulary of other signals. Dr. Lilly, who has done experiments of this kind decided on studying the dolphin for several reasons:

. . . for example, the dolphin has a brain approaching man's in size and complexity; it probably has the ability to learn an interspecific

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<sup>18</sup>William F. Evans, Communication in the Animal World, p. 131.



language; it is similar to man anatomically and physiologically; it is not too large to deal with; an empathy is usually established between a subject and investigator; the dolphin can and does make humanoid sounds, often mimicking our speech; and at least one species--the bottle-nosed dolphin--is easily obtained in the warm waters along the Florida and Carolina coasts, near the Virgin Islands, and elsewhere.<sup>19</sup>

The young mammal is taught dolphin language twenty or so months before it is weaned. Lilly believes the cultural history of the species is passed on during this time. Dolphins have no written history and must use oral communication. Many primitive human tribes use this method today.

Communication of dolphins is probably complex and highly descriptive. Lilly believes these animals may be every bit as intelligent as man, although in a different way. He says some above-water sounds of dolphins--made only in the presence of human beings--resemble human laughter, whistles, cheers, and syllables in a high-frequency range. They try to communicate with man by lowering their vocal frequencies to audible ranges and vocalize in air rather than in water for human benefit. Lilly counsels that it is necessary to keep in mind that the subject must be exposed to human vocalizations for a long period of time and everything must be done to secure a mutual friendship between the man and animal.

Lilly coaxed dolphins into producing audible sounds in air or water. Human vocalizations were emitted alternately above and beneath the surface of the water. Underwater speakers and microphones, or hydrophones, were placed in tanks containing the mammals. They became accustomed to the sounds of human voices and in turn conveyed sounds to speakers in the laboratory.

The mammals initially emitted only the usual dolphin sounds. Later, whistling games were played between the dolphins and investigators. They mimicked many human sounds, including letters of the alphabet and laughter. These were often made and directed to the dolphins by Mrs. Lilly. The mimicking sounds are unintelligible until they are recorded and played back at a slower speed. It is evident that these big mammals compress our own drawn out words into tiny spurts

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<sup>19</sup>Ibid., p. 131.



of continuous sound.

### Conclusions and Recommendations

Cetaceans are the only nonprimates possessing a highly efficient and complex "language." Dr. Lilly's investigations will determine if extensive communication with them is possible, whether all dolphin "language" is the same and if there are certain "dialects" for different areas. Even if the efforts are unsuccessful, what has been learned from aquatic mammals can be applied to communication with other species.

The movie and novel The Day of the Dolphin by Robert Merle spurred my interest in the possibility of oral communication between marine mammals and man. Although fictitious, the story accurately portrays the intellectual capacity of the dolphin, an excellent representative of marine mammals.

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SEAMAN'S BEST FRIEND  
by Heather Carvalho and Gail Silva, Sacred Hearts Academy

Abstract

This report includes the "how to's" and "why's" of dolphin training. Each stunt is taught in a unique way with constant attention and patience. Dolphins are trained to do stunts for marine entertainment parks in many places. Most of this research paper uses examples of the dolphins at Sea Life Park on Oahu. Dolphins are loveable and intelligent, the perfect animal for performances.



## INTRODUCTION

Dolphins have been the subjects of books, magazine and newspaper articles, motion pictures, and television series and specials for several years now.

People have had this great interest in dolphins for at least 2,500 years. We can find pictures of dolphins, or animals with a very similar likeness, on Greek coins and pottery along with drawings that were made before the time of Christ.

Dolphins have been the good friends of seamen for many years because the men thought that they brought them good luck.

The modern-day interest in dolphins began in the late 1930's. Just after W.W. II, people became aware of the fact that dolphins could be taught to do many tricks.

Dolphins are extremely responsive to humans, and they show a great deal of individuality in their behavior. This, along with their intelligence, tends to lead people, even those who use them as experimental subjects, to think of them as humans.

One area that makes the dolphin so advanced is their highly social behavior. This has been the cause for humans trying to communicate with them for so many years. Up to now, they have been unsuccessful, because they say humans are too dumb, but they are still trying.

In this report, we will try to cover the "how to's" and "why's" of training these marvellous geniuses of the sea.



## SHAPING

Shaping is the reinforcement of a certain trick. The reason for shaping is to perfect certain stunts the dolphins already does naturally, or to add on to ones he has learned.

Shaping is the most important area of training. Actually, it is the main training for the dolphins. The reinforcement is usually a fish or a whistle blow. These are signals meaning "well done" or "keep trying."

There are certain steps to shaping a dolphin. In order to explain this I will use the example of a trainer who wants a pair of dolphins to jump over a bar.

Dolphins and porpoises are afraid of things that don't live in the ocean and seem to have no scent, sound, or movement. Naturally, the dolphins were frightened of the bar.

Step One was to overcome their fear of things like bars, while trying to give them some kind of idea of what was wanted. The trainer then put a rope on the floor of the tank. The dolphins refused to pass to the other side of the tank because it meant passing that strange object lying so still, maybe ready to eat them. So, the trainer tried bribery with fish. She got into the water with some of their favorite toys and called to them. They refused. She then got out of the tank and tried to scare them over the rope by throwing a beach chair at them. It worked! As they passed the rope, the reinforcement whistle came and many fish followed. They now weren't afraid of the rope and understood what was being required of them. After a few more crossing they were doing it readily on their own.

Step Two is to give them a challenge. The challenge was to lift the rope up half way through the tank. This gave the dolphins a chance to make a mistake by going under the rope. Once they knew they had to go only over it, Step Three



began.

Step Three was to gradually lift the rope to the surface so they'd have to jump over it, and not just swim over it. After they jumped the surface rope, it was raised higher and higher into the air. Each time they crossed the rope, they were rewarded. THE DOLPHINS WERE SHAPED TO JUMP A BAR ABOVE THE WATER!!!

### SIGNALING

Signaling is the use of cues to tell the animals when to do a particular stunt. The reason for signals is simply for communication between trainer and dolphins. The dolphin must learn exactly what that cue means and to obey it whenever it is heard.

There are two main types of signals. The first is hand motions and the second is underwater electronic sound systems.

For many years hand signals were used, but problems came up too often because of them. Different trainers had different signals, and even the slightest change will confuse the dolphin. Then they will go into a corner and sulk, get sick, etc... So, if a trainer had a day off or was sick, the shows just had to suffer. The second reason problems arose from hand signals is that dolphins are not seeing animals as much as they are hearing animals. The image of the signal is often blurred and once again the poor animal becomes confused.

The underwater electronic sound system is much more advanced and practical than simple hand signals. The advantages of the sound cue are great. If the dolphin is on the opposite side of the tank, the trainer doesn't have to get its attention so that the signal can be seen. Sound cues are heard throughout the tank. Next, dolphins are hearing animals, so they can easily distinguish one sound from another. Trainers are able to take vacations or rotate without the worry of the show suffering, since the sound cues don't change. The response



is also much faster. There are some problems with this system. The main problem is that the trainer himself cannot hear the cue while he's out of the water. There have been times when the trainer thinks that all of a sudden the dolphin forgot all he learned, or that he is sick, when it's actually because the main switch was not put on. These were the types of signaling.

There are also rules to signaling. They are extremely important so that the dolphins don't get confused.

- A. Never time your stunts at exact intervals. The dolphins can pick up on this, and soon they'll be spacing their stunts at those intervals-not by the signal!
- B. Leave the cue on longer than it's off, so they learn that the sound means to do the trick and no sound means no trick. This is called Stimulus Control.

#### STUNTS

Dolphins and porpoises have been trained to perform many tricks. These include high jumps, jumping over bars, doing the hula, wearing leis, beaching into a beautiful pose, ringing bells, and somersaults. Of course, there must be many others, but this proves the flexibility, intelligence, and friendliness found in these wonderful creatures.

High jumps consist of having the dolphin jump straight into the air to begin. Gradually the animal is only reinforced as he jumps higher than before. When the goal of the trainer is reached, a fish is held at that height and the dolphin's new goal is to Get That Fish! This is a relatively simple trick for a trainer since the animal is a natural jumper in the open seas.

Jumping over bars is a gradual process beginning with a rope at the bottom of the tank. It's then lifted half way up the tank to reinforce going over



and not under the rope. Little by little the rope is moved up until the trainer has them jumping over the bar to her or his satisfaction.

The stunt of doing the Hula is actually the dolphin balancing on its tail fin in one area of the water. This is done by first reinforcing the tail balancing; then the trainer puts a hoop around the dolphin to keep it in one place.

You might not think wearing a lei is a stunt, but it is because plastic leis can irritate the dolphin's soft, sensitive skin. This stunt takes alot of patience on the part of the trainer, and endurance on the part of the dolphin. The only way to teach this is to keep putting the lei on, enforcing it, putting it on again, etc...

Beaching is when the dolphin comes to the edge of the tank and pulls itself up to the deck. It then poses for us in a beautiful arc. This was taught when a dolphin would, out of play, beach itself and get reinforced.

When you see a dolphin ring a bell the next time you see a marine show, please appreciate it. This is a very difficult thing to teach a dolphin. The trainer must get into the water and sometimes push the dolphin's nose against a paddle to make the bell ring. The dolphin resents this, so it takes alot of time, and patience. Once it is learned, the dolphin enjoys ringing it as a new toy. Again, reinforcement is used every time the bell is rung.

The somersault is another natural stunt that has to be enforced whenever a dolphin decides to do it. Since dolphins are quick to learn and like to do somersaults, it is easier to do than some other stunts. Reinforcement is absolutely necessary!

#### PROBLEMS

The first headache obtained by dolphin trainers is the problem of giving antibiotics to newly captured dolphins. The trainers complained that the antibiotics were the cause of fights and unhappy moments in the relationships between



dolphins and trainers, but the scientists claimed that they never administered antibiotics for "no reason." They later discovered the answer. When a dolphin is captured, its body can't fight off the new germs that he was never exposed to in the ocean. The animal's resistance to these germs is so low that he may die within four or five days in captivity. Aside from this problem, there are also many mechanical problems. The electronic cues used to signal the dolphins, along with the P.A. system, were exposed to salt water and weather conditions daily, which caused many problems.

The workers are human so some problems were mistakes. An example of this is when the chlorine drip for one of the tanks (chlorine was to prevent bacteria growth) was left too high, and the dolphin suffered for days. The trainers wondered why he wouldn't eat, and one day they found out. Someone had thrown a fish into the tank, and since the dolphin didn't eat it, it had to be taken out before it rotted. One of the trainers jumped in, and was instantly blinded. His eyes were quickly washed out until he could see again. The chlorine content was strong enough to bleach laundry.

The dolphins also put in their share of the problems. They thought it was fun to teeter over the walls of the tank. Because the water content was so high, they managed to get up there, but they often fell out onto the hard ground below. They suffered a few scrapes and bruises which wasn't what the trainers feared the most. They were afraid they might fall out during the night, dry out, and die. This could very well be, because if no one was around to put them back in the water, they could indeed die. If the animal was small, there wasn't too much of a problem; but when the 400 lb. bottlenosed dolphin fell out, it took lots of muscle to return it to the tank. The trainers would yell at them, but this just seemed to make the game more fun. Fortunately, they eventually got tired of this game.



Another favorite pass-time of the dolphins was smashing into the gates of their pens. Many dolphins have been known to break through their gates, and find their way into another dolphin's pen, even if they don't like their neighbor.

Dolphins do get angry with humans and other dolphins, but they will always give a warning by making a clicking sound with their blowhole, or they will "buzz" a swimmer, by zooming by and making an especially loud sonar blast. In some cases the next action might be to strike the swimmer or other dolphins with their tails or dorsal fins. In cases like this, the dolphin must be trained to do something else while swimmers are in the water, or if they can't be distracted from the swimmers, they must be penned up until the swimmers are out of the water. Although they might frighten people, they very rarely hit anyone.

Although there may be many problems involved with training these animals, there are far more rewards.

#### CONCLUSION

We hope that the readers of this report agree with us that dolphins and porpoises are extremely talented and loveable creatures. They seem to respect us as we should respect them. If they didn't we would never have been able to train them.

For further details and information, we recommend the book Lads Before The Wind. It's a very informative, factual book on the training of dolphins and porpoises at Sea Life Park.

NOTE: Although this report only refers to dolphins, porpoises are also subject to all areas of this report.



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HAWAII'S MARINE MAMMAL--THE HUMPBACK  
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ABSTRACT

As man continues to invent more and more products, which need combustible substances such as oil, we also search near and far for these substances. Man has searched in the earth, by drilling through the crust in search of oil. But this wasn't enough. Man has also discovered that some whales are also rich in oil. One of the most common of these types of whales is the Humpback. They migrate to the Hawaiian waters annually. Here they are protected from whalers of other countries. My report is about this cheerful whale - the humpback.



## INTRODUCTION

When the waters of the Arctic gets too icy cold, whales migrate to tropical seas. A lot of humpbacks are seen during the winter months in the waters between Maui, Molokai, and Lanai. They have been known to be the most athletic and playful of all whales.

## CLASSIFICATION

The Megaptera Novaeangliae, better known as the humpback has many other names such as hump or bunch. These cetaceans are part of the Mystacoceti class of baleen whales. Baleen whales have no teeth and capture their food with the humpback's baleen or whale bone. But there are still further subdivisions, that the humpback is a part of. They are part of the rorquals of Balaenopteridae. This division has short baleens, a dorsal fin, and 70 to 100 grooves on their ventral side. (See Fig. 1)

## CHARACTERISTICS

The Humpbacks are 40 to 54 feet long with huge flippers  $\frac{1}{4}$  to  $\frac{1}{3}$  of its total length. They can be easily identified from other rorquals because of their long, distinctive fins. These giants are averaged to be 29 tons which accounts for their speed. They are slow swimmers, as slow as 1.3 to 5 knots, therefore can easily be caught by whalers, using primitive methods. They have black tops and sides but their ventral side is white. One humpback whale was found to have 1000 pounds of barnacles adhered to it.



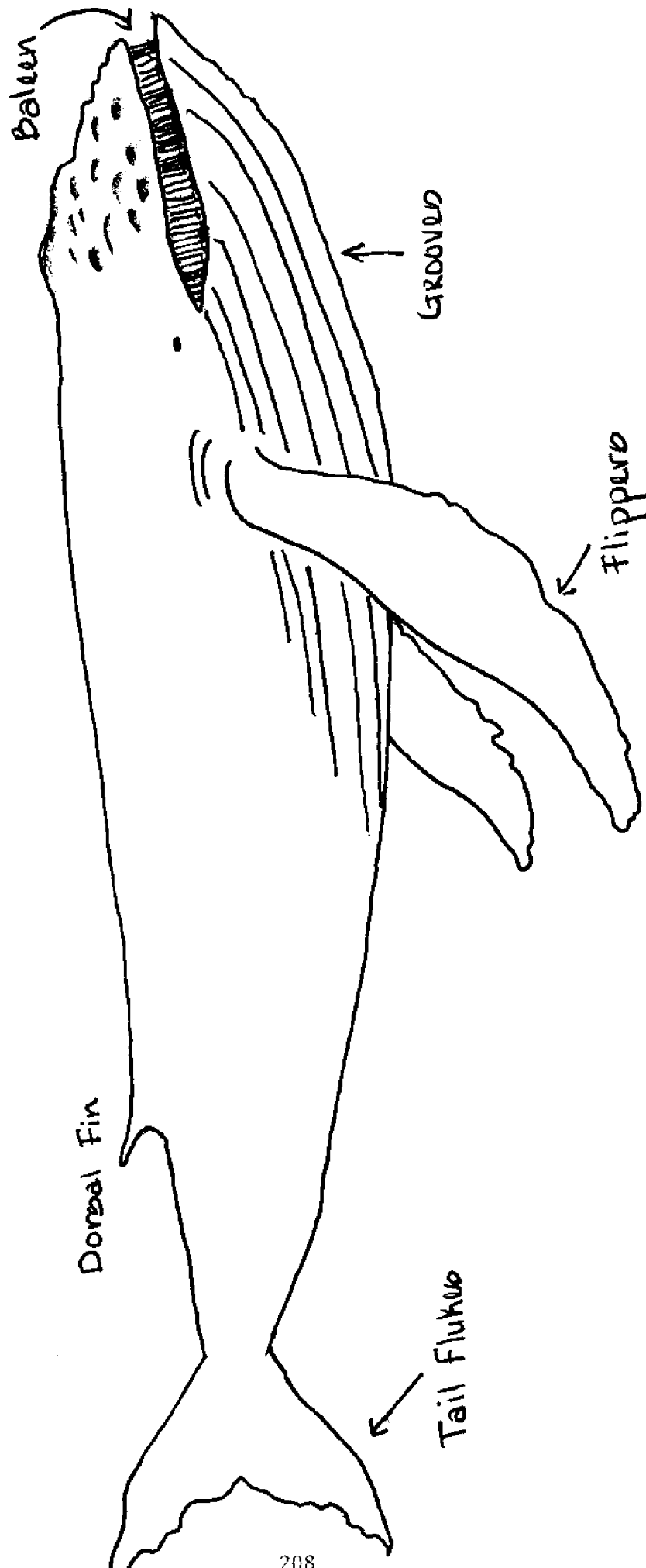


FIG. 1

The Humpback Whale



## INTERESTING FEATURES

These whales have gained a reputation for being the most athletic and playful of all whales. Their frequent leaps clear out of the water, partially spinning and falling back with a mighty splash can be heard and seen for miles.

Humps are often known as the singing whales. The humpback has a long and complicated, melodious song, which is also unique from other whales. It has been studied and found to have a definite pattern and has been used as the background of a new symphony. Whale watchers have been observing the song to be changing every year and has determined that the Atlantic and Pacific humpback whales' songs vary in composition. Their song usually lasts 3 to 36 minutes but has been recorded for hours or more depending on the certain singing humpback. The song has been heard to be repeated almost identically with the only difference in the tone. Scientists believe that higher notes indicate the changing of their feelings. Humpbacks are able to find each other over large stretches of ocean. With their low-frequency sounds throbbing outward for miles and miles, they communicate information about their species and location, if there are no obstacles.

As you might already know, humpbacks are very friendly. If you are aboard a ship cruising in the waters between Maui, Molokai, and Lanai, and a few black sea creatures with spouts come suddenly swimming along the side of the ship, do not be afraid for they are the friendly humpbacks. They are known to come from the sea, unexpectedly and sail with ships that are not whaling ships. They have been known also to support a wounded comrade until they themselves fall victim to whalers. Humpies also come to the assistance of pregnant females and their young.



## REPRODUCTION

The humps migrate to Hawaii, some to mate, others to give birth. Scientists have watched the bulls, or male whales, when attracting attention of the cows or females during mating season. They stand with their heads underwater, while smacking their tail flukes on the surface. (See Fig. 2) Once the bull attracts attention, they both may rise vertically out of the water with their stomachs facing each other. (See Fig. 3) Observers have agreed that the mating act is preceded by prolonged and tender foreplay. For example, the pair could make swimming motions in each other's direction and stroke each other with their bodies and flippers.

Both sexes have the same organs as do all other mammals. Except that the male's testicles do not lie in a scrotum outside the body, but at the rear of the abdominal cavity behind the kidneys. The females sex organs are in the exact same place in the abdominal cavity as the male's testicles are.

The females sex organs consists of a vagina with a heavily folded mucous membrane, a two-horned uterus, the Fallopian tubes, and the ovaries. The ovaries of the humpback look like clusters of grapes. A pink corpus luteum develops from the empty follicle shell after ovulation. It produces hormones which helps the embryo, attach to the wall of the uterus. Like all mammals, if the ovum is not fertilized, it will shrivel. The newborn comes into the world, tail first and must be able to swim to the top, for his first breath. Once the calves are born, they are like cow calves. They get their nourishment from their mothers, but they cannot recieve warmth from her, and they must swim along her right side. The chances for a female whale to give birth to twins and triplets are the same as a human beings.



Male Humpback  
Mating Call

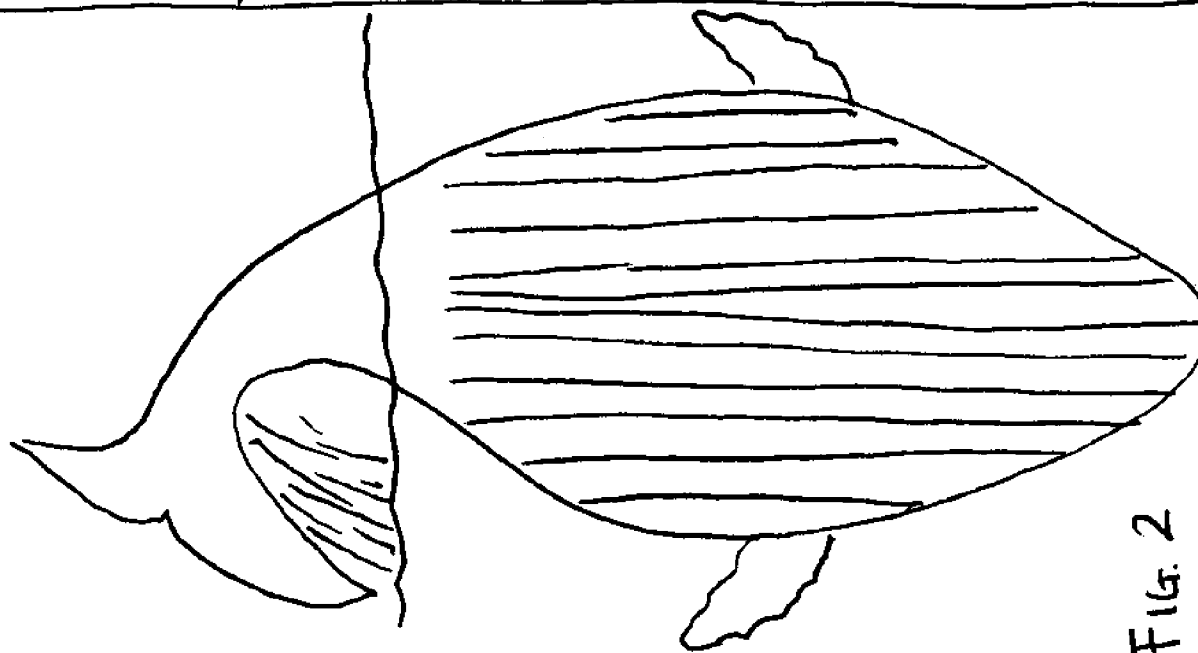
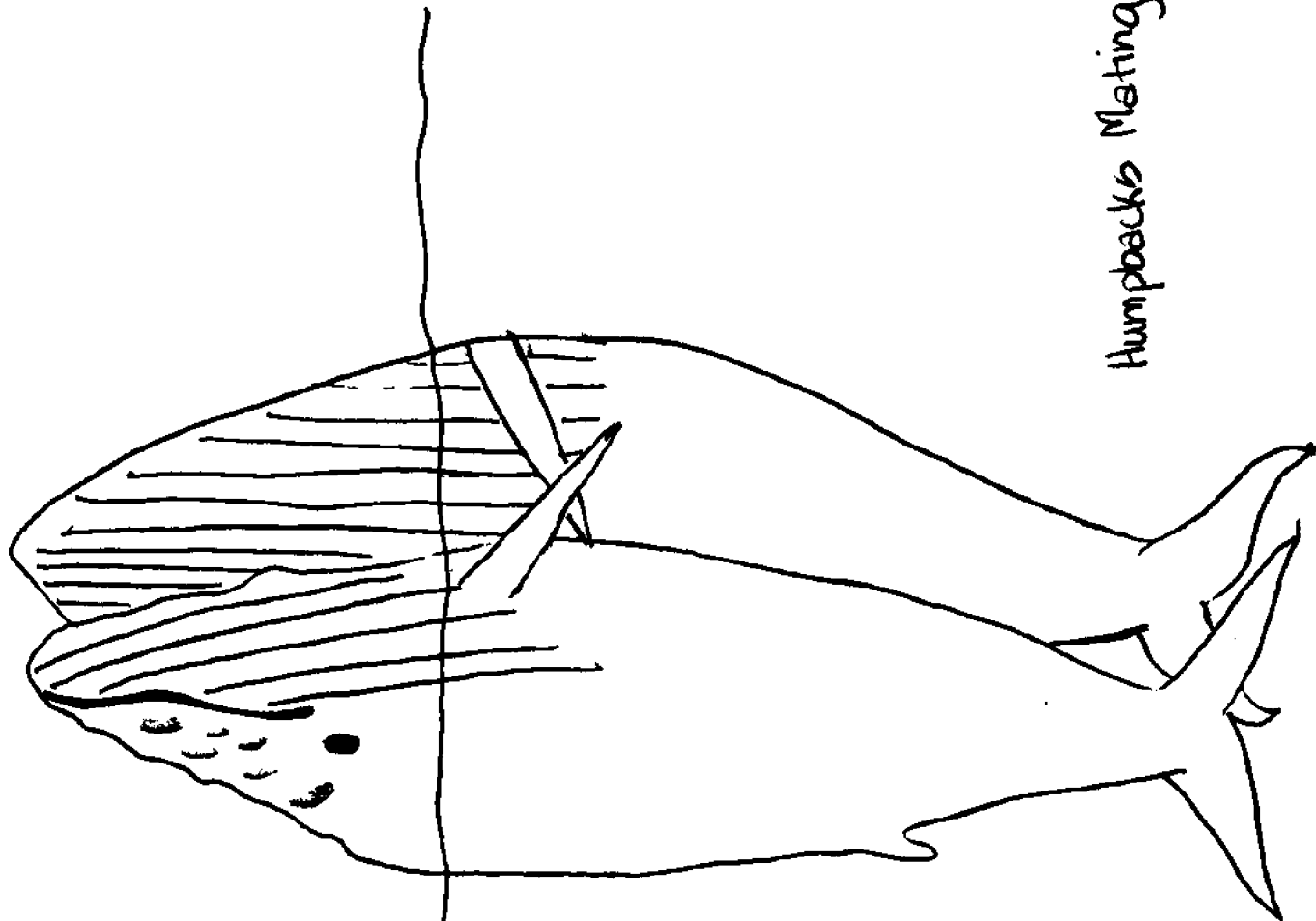


FIG. 2



Humpbacks Mating

FIG. 3



The birth process of the great whales has never been observed. The information that I have found was only from females that were stranded or captured during birth. There is no way for whalers to know that whale cows are pregnant until they are harpooned. This is why, there is not much more whales in the world today. Whales are like people, but they can not keep up with mankind. Female whales can only bear between 6 and 15 young in her lifetime of 15 to 30 years. If she is allowed to live that long.

#### CONCERNING HAWAII

In Ancient Hawaii, whale meat had a minor importance as food source. When whales were washed on the shores they were valued and were the property of the chief. Whaling was important to Hawaii because whalers used the islands for refueling and supplies. This lasted 50 years, from 1830 to 1850.

Pleasure crafters today, on the Kona coast of the Big Island, are worried about the danger of whales leaping clear out of the water unexpectedly and crushing the boats.

#### PROTECTION

The humpback whale was adopted by the Hawaii State Legislature in 1976 as the official marine mammal of our state. Waters between Maui, Lanai, Molokai, and Kahoolawe were declared the first whale preserve in the United States. This proclamation states that the migration months for humpbacks, December to May, will be whale reserve months in the county of Maui. The humpbacks are protected from whalers during these months.



In the beginning of this century the humpbacks were not considered endangered. Only in the late sixties humans began to realize that the whales of the world were in the process of extinction. But nothing was done, until the United States proclaimed the Marine Mammal Protection Act of 1972 and the Endangered Species act of 1973. Many organizations were established to save the whales.

The most famous, in Hawaii, is Greenpeace. It operates out of Vancouver, British Columbia, and has a branch in San Francisco. Greenpeace believes in the direct approach. They look for whalers. When they spot pods of humpbacks, or any other whales, they send rubber boats to go between the whales and whalers' harpoon boat. Many people are now aware of the near extinction of whales and other cetaceans. But there are still some who need these whales to live.

#### CONCLUSION

I have never seen humpback whales before. But as humpbacks still live in the world's waters today, I hope there will always be these friendly, athletic, playful, and harmonious whales in my years to come. I have learned a lot about the humpback. But there is still more to know. The world should realize the happiness of having such sea mammals to delightfully watch and someday learn more about.



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# REPRODUCTION OF HUMPBACK WHALES

by Angela Park, Hana High School

## INTRODUCTION

What kinds of safety laws and programs are there for humpback whales? Why have they become an endangered species? Humpback whales are enormous animals, when fully grown, they are 45 feet long and weigh over 40 tons. Newborn calves weigh close to 2,000 pounds. They are non-aggressive and show no feeling of hatred toward man; they are usually known as the peaceful giants.

## RESULTS OF RESEARCH

Humpback whales are the most common off the coast of Washington and all around the Hawaiian Islands. The whales have gained a reputation of being most athletic and playful by the way they leap clear out of the water, spinning and falling back with a mighty splash.

Their main foods are anchovies and krill, which are found in the northern fishing grounds and are gathered from May to December. Krill are shrimp-like animals that measure up to  $2\frac{1}{2}$  inches in length but are usually only  $1\frac{1}{2}$  inches long.

The humpback is up to fifty-four feet long with huge flippers that are one-fourth to one-third its total length. The average length of a humpback is forty feet.

It has an average weight of twenty-nine tons. These whales are slow swimmers and can easily be caught by whalers, who use primitive methods. They stay under water for four to seven minutes between breaths.

The humpback has a low, broad, jet-shaped spout, that goes along with a puff. Humpbacks' reproduction involves considerable loveplay. They do it by caressing each other, slapping each other with their flippers or gently



swimming past one another with bodies gently touching. They mate, facing one another, chest to chest, and rising to the surface at great speed. The gestation period lasts ten to thirteen months. The calf is sixteen feet long at birth. At three years sexual maturity is reached in both male and female humpbacks.

Humpback whale courtship usually involves a lot of leaping and splashing out of the water, and playful taps with their flippers. As soon as the excitement is over, the pair mate belly to belly, usually lying on their sides or sometimes rubbing themselves together in a vertical position in the water.

The single young calf is born tail first, otherwise the calf might drown while coming out from its mothers' body.

Most whale mothers are protective and caring toward their young. Among different types of whales that travel together in groups, an "auntie" or "midwife" often swims close during the birth process and helps the mother push the newborn to the surface to get its first breath of air.<sup>1</sup>

The nipples of the mother whale are enclosed in slits, one on either side of her reproductive opening. Whale milk is a rich and highly condensed food, consisting of as much as 40 to 50 percent fat and 12 percent protein. On this fare, the youngsters grow quickly and steadily.<sup>2</sup>

The whales' sense of smell is of little use, because during dives their nostrils are closed tightly. Above their eye is a tiny opening, almost invisible and about the size of a pencil lead, which is the ear. In spite of this small opening, the whales' hearing is very sharp. It receives many sound vibrations through its head and the forward portion of the body. The sounds are thought to be produced by methods that include the movement of air in the nasal passages, since the whales have no vocal cords. Whales use a variety of sounds to locate one another in the ocean and to communicate often a mix of pure notes, chirps and chords; these whale sounds can be very powerful.



Like all other marine mammals, whales descended from early land mammals that, at some point in their evolution, returned to the sea. Some sixty million or more years ago, whales, along with dolphins and sea cows, came from plant-eating, hooved mammals that adapted to life in the sea. Gradually developing and changing over a great period of time, the whales became one of the most specialized of all modern mammals.<sup>3</sup>

For centuries, men of many nations have been killing them off, in tremendous quantities. They killed whales for a lot of things, such as oil for lamps and a high grade lubrication oil, male whale cells for candles, ambergris for the best perfumes, and whalebone for padding and undergarments.

The Washington State Commerce Committee approved a bill restricting the capture of killer whales for display in commercial attractions. In 1935 a serious attempt occurred to slow down the killing of whales in the Antarctic. It happened when the whaling nations agreed to forbid the hunting of right and bowhead whales, which were almost extinct by this time, and to stop the taking of female whales while a calf was nearby. In 1966 the International Whaling Commission (IWC) finally protected both blue and humpback whales. The action was almost too late, for both species were already close to extinction.

There are two federal laws that protect the humpback whales. Both the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973 prevent the taking of humpback whales.

On December 12, 13, and 14, 1979, on Maui, there was to be an important meeting discussing a proposed sanctuary for humpback whales in the Hawaiian waters.

Scientific experts and government officials were to attend the meeting. According to Jo Ann Chandler, acting director of the Sanctuary Management Office, the objective of the meeting was to come up with some guidance from a scientific perspective as to what program is best. Ms. Chandler was quoted



as saying, "It is a three-day scientific gathering which brings together many of the top national and international experts on the subject that will cost about \$10,000."

According to a 34 year old former San Francisco attorney, "It is clear that the humpback has been, is and will be put together by human activity."

Since there was an increase in the number of people expected to attend the meeting for the protection of the whales in Maui's waters, the Lahaina Restoration Foundation decided to reschedule the opening sessions. The three-day public session was held in the Mokihana Room of the Maui Surf on December 12.

The workshop was sponsored by the Office of Coastal Zone Management of the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

According to a Coastal Zone Managment statement, the humpback whales come to Hawaiian waters each winter to calve and raise their young, as well as court and mate. Their conservation depends, partly on the protection of the species during crucial periods in their life cycle.

Among the topics discussed were: the life history characteristics of the humpback whales, experimental conditions necessary for survival, activities which may affect the whales, potential mechanisms to increase the present protection of the whales, criteria which local, state, and federal action should fulfill, and research and public education priorities.

"The meeting was the result of a 1977 proposal, written by James Hudnall, asking for a protected sanctuary in the waters bounded by Maui, Molokai, Lanai and Kahoolawe." "This is the second time a group of scientists have met in Hawaii to discuss the problems of the humpbacks." "The result of the workshop was a definition of harrassment which federal agents could use to enforce the Marine Mammal Protection Act."<sup>4</sup> "The panel is proposing the sanctuary extend



from Kuala Island to the Big Island, covering the waters from the shore out to the 100 fathom ledge."<sup>5</sup>

"Instead of Hudnall's proposal, he recommended the panel consider establishing a 24-hour whale hot line to take calls on harrassment, as a depository for data collected by scientists on the humpbacks in Hawaii, and uniform harrassment rules enforced all over the Hawaiian chain."<sup>6</sup> The panel ended December 14, and will publish its recommendations in February.

#### CONCLUSION

I have chosen this area to study, because I feel that saving the humpback whales is a very protective thing to do. Although I do not know too much about humpback whales, I for one, think that having a sanctuary for humpbacks is the greatest thing anybody would consider doing. By doing my research on humpbacks, along with their characteristics, I have felt myself become more interested to know more about them, such as, what is really going to happen to them in the near future.

I have done quite a lot of research on these whales and now, looking over it, I am glad that I was able to write a paper about this important type of whale--the humpback.



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# Heritage of the Sea







THE HISTORY OF WHALING  
by Craig Rowland, Roosevelt High School

**Abstract**

My report is on the history of whaling from its early days to the present. I will cover the different methods of whaling and also advances in whaling technology. I will also talk about the International Whaling Commission and whale conservation laws.



## THE HISTORY OF WHALING

Whaling started in many different places and with many different techniques.

In some European countries, such as France, Spain and Iceland, lookouts would be situated on the mountains and in towers. When a lookout spotted a whale, whalers would venture out and harpoon it. Since they did not go far from the coast, each village took only one to six whales a year.

Around the middle of the sixteenth century, Europeans began looking for more and bigger whales by going on long sea voyages. They would sail to a bay and stay there for a whole season.

Long before this, the Eskimos had been hunting whales in a different manner. These people, riding in twenty-five foot long vessels, would shout as loudly as possible, supposedly to make the whale stop for a moment, thus giving the harpoonist a chance to throw his harpoon. The harpoon was connected with a line to a number of buoys made of animal skins. The man who planted the first harpoon would take charge of the whaling party. When the whale came back up after diving, it was harpooned again. Thus after a while the whale would be further extinguished by the leader as a hole was cut in the whale's side through the blubber. A final lance was then jabbed through the hole. The whale having been killed in this manner was towed to shore and allotted among each member of the party.

Indians at Vancouver and Queen Charlotte's Islands used similar techniques in whaling. One difference was in the materials used for the harpoon heads. The Indians used mussel or abalone shell, whereas the Eskimos used ivory or stone harpoon heads.



A very unusual method of whaling was used by the Aleuts. Using only one or two man kyacks, they would make a stab at the whale with a poison-tipped spear. The whale died within a few days and might or might not be washed up on the shore. The mark on the spearhead identified the hunter who had killed the whale. The whale was usually shared with the finders. The poison was made from fermented aconite root. When the Aleutian Islands were first discovered by European explorers, the Aleuts tried to keep secret the method of making the poison. They told the explorers that the poison was made from oil which had been boiled out of a dead rich whaler. This method of whaling was also employed by the natives of Kamchatka Island and Kurile Island as well as by the people of Hokkaido, Japan.

The rest of Japan, however, used a different technique. Their technique was similar to that of the Europeans. Harpoons were attached to their boats with lines, but they also used nets. The whales would be chased by boats into shallower water where the nets were waiting. Once the whale was entangled in the nets, the harpoon boats rowed near and planted their harpoons deep into the blubber. The whale was harpooned as many times as it surfaced. When the whale was near exhaustion, the lancing began. Some whales had to be stabbed in over a hundred places, but other, smaller whales needed only two or three stabs to kill them. Before the whale died, a hunter jumped up on its head and cut a hole in the end of its snout. A rope was tied from this hole to one of the boats. After this two boats lined up on either side of the whale and men with ropes swam under the whale and made a support of rope between the two boats. After this was completed, the whale



was finally extinguished with lances and long knives. The whalers all chanted "May its soul rest in peace" and "Thank God and Buddha for the whale." The whale was then towed back to the shore where factory workers began work on the whale.

American whaling began in the middle of the seventeenth century. At first only coastal whaling was conducted, but then as whales got fewer in number they went after bigger and more whales. The height of the American whaling occurred in the middle of the nineteenth century, with about seven hundred whaling ships operating. In 1849 however, many whalers left the sea to look for gold. The Civil War also took many whalers away from the industry. After the war petroleum was discovered and the demand for whale oil began to drop steadily. Besides the American sperm whalers all over the world, there was a North Pacific fleet that worked in the Arctic. Most of this fleet was crushed by the ice in 1871. Thirty-four ships out of forty-one were stranded by the ice, but not one man out of one thousand was lost. Whaling also took place in the Hawaiian Islands, starting around 1819 and lasting for approximately fifty years. Lahaina, Maui was the whaling capitol of Hawaii. The whales caught were humpbacks which migrated down from the Arctic to breed and spend the winter. American whaling ended around 1914 with the outbreak of World War I. After the war, an effort was made to revive the industry, but when the "Wanderer," the last American square-rigged whaleship, was wrecked the day after she put to sea, it was the end of the fleet. Although the United States put restrictions on the kind of whales killed in American waters, a total ban on all U. S. whaling did not come until 1972. Thirty-nine whales were taken by the last shore station at Richmond, Calif.



Many changes have taken place since the early days of whaling. One of the bigger changes was that of the explosive harpoon. It was invented in Britain in 1840 and developed in Norway by Svend Froyen. The present-day harpoon has a four-barbed warhead which contains a grenade. The grenade is exploded by a time-fuse. Another big change was the introduction of steam power. With faster boats, faster whales could be caught. Up until then, blues and other large whales were too fast for man-powered boats. The first factory ship put to sea in 1925. The factory ship made it possible for whaling ships to stay out longer than they could before. It was possible to process a whale on board while catcher boats pursued the rest of the pod. By 1930, there were thirty-eight factory ships operating in the oceans of the world.

In 1946 the International Whaling Commission was formed to protect "the great natural resources represented by the whale stocks." The Commission did not do very much except to divide up the world whale population among its members. For years the Commission set quotas higher than the numbers they knew the whalers could catch. They also had a rule that any nation can be exempt from any rule that it doesn't like. In 1972 the U. S. delegation proposed a ten year moratorium on all whaling. This moratorium was not passed until 1979. The moratorium calls for no factory ship whaling except for that of the small minke whales.

The whaling ships are getting rusty and will not be replaced. Hopefully, the whales can hold out until the ships are gone.



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ANCIENT FISHING METHODS  
by Alice Jean Motooka, Hana High School

INTRODUCTION

Living in a community where the Hawaiian culture is still preserved, I decided to do my research on ancient fishing methods still used in Hawaii today. I used library resources for descriptions of ancient Hawaiian fishing methods and talked to modern fishermen to get information about today's methods.

RESULTS OF RESEARCH

Customs Concerning Fishing

For ancient Hawaiians, the ocean was relied upon as a travelway, playground and a place to get their main source of food. The majority of their protein came from marine life and little from land animals.

Everyone from the keiki to kupuna went fishing, either as a sport, work or just for fun. The keiki would play in tidal pools, catching black crabs and picking off pipipi. The wahine spent days collecting reef fish and limu in their ipu. The kane would do the more challenging and difficult methods in deeper waters.

The Hawaiians worshipped Ku'ulakai, the god of fishing, and constructed shrines along the shore. Each fisherman had a personal fishing god called an 'aumakua. The gods usually took the form of a plant or animal. The fisherman would pray and offer fish at the shrines. For important ceremonies, priests offered certain kinds of fish to the gods. Alii ate only certain kinds of fish that the common people could not eat. The red and white colored fish were usually used for the ceremonies.

A man could not become a fisherman by just going down to the beach to fish. There were many preparations before becoming a fisherman. They were honored



people and not anyone could become one.

The fisherman had to make careful preparations before going out to fish. There were strict kapu which governed the making and lashing of the hooks. When hooks were to be lashed, the fisherman warned the family the day before, so no kapu was to be broken. No one was allowed to peek in windows or doors, run in and out of the house, or make any kinds of noise. Everything had to be done in complete silence and no one could interrupt the fisherman or look at his work. No one could ask him questions, talk to him, or visit him. Lashing had to be done at a particular time of the day. It had to be done in the afternoon and could never be continued after sunset. If the fisherman could not finish before sunset, he would put his work in anipu very carefully and place it near the ceiling. He would never touch it again until the afternoon of the following day. When everything was completed, the hooks and lashing, the fisherman would go to a corner of his house to say a prayer to his 'aumakua.

The fisherman's wife was not supposed to gossip, sleep, or quarrel with anyone while her husband was fishing. On the way to the canoe landing, the fisherman was not supposed to talk to anyone. If he should meet a blind man, he must turn around because this would bring him bad luck. No one was allowed to call or talk to anyone else in the canoe. In the canoe, no one was permitted to speak to the fisherman. All eyes were forward; the men paddled and watched in silence until they arrived at the fishing ground.

The first fish caught each day was marked by cutting off its tail. This fish was given to the fisherman's 'aumakua. As soon as they returned to shore, the fisherman took his first fish to the shrine and offered it as a sacrifice. This was done to bring luck and success.

To become a fisherman, one had to accomplish certain ceremonies. As soon as a beginner caught his first fish, he could not continue. He would return to shore and give his fish to an old fisherman or to a kahuna. The man who got



the fish would cut it into small pieces, wrap them in ti leaves, and cook them. The cooked pieces were placed on a table and the novice fisherman said a prayer to all the 'aumakua of the East, North, South, West, Sky and of the Deep Sea. All of the advanced fishermen were invited to attend the ceremony. After the prayers were said, all the fishermen sat down to eat. Although the observers were not invited, they could help themselves without an invitation.

The new fisherman would collect all the fish bones from the table. He would return them to the sea followed by a prayer. After this ceremony, he was now considered a fisherman.

Every fisherman had to know all the arts of fishing. The managing of his canoe was also important. A canoe that was overturned demanded a great deal of skill and hard work. Sometimes the task took them all day in the water. The Hawaiians were not afraid of sharks. If one of their favorite hooks was bitten off, they would dive in and try to get it back.

Ancient Hawaiians preserved their fishing grounds by having kapu. A certain area was off limits for a month while another was opened. Also, certain kinds of fish or other sea resources could not be taken at certain times of the year.

#### Fishing Methods

Hand fishing was a simple and inexpensive method used by both sexes in shallow water around rocks. They would dive down and thrust their hands around rocks and corals where the fishes would not be able to escape. This method took alot of skill and patience to be able to catch a fish with bare hands.

Nets were not introduced to Hawaii until the Japanese brought them in the 1890's. The Hawaiians quickly adopted this method because of its effectiveness along the shore lines. The Hawaiians made their net twines out of the fiber of the olona or hopue plants because of its strength and lightness. The weights on the outside were made of shells, rocks or pieces of coral. The nets had



different shapes and varieties.

The throw net is still popularly used for catching fish that swim in schools near the shore. After throwing the net into the water, the fisherman jumps in and gathers up the open bottom of the net to trap the fish in. Throwing a net takes a lot of practice so it will open properly. Most beginners start by using a small net. Fishermen today often use Polaroid sunglasses to help cut the glare of the water so they can see the fish.

When Hawaiians made their nets out of the olona plant, they would cut bundles of the plant shoots and soak them in running water for four to five days. When it became clean, they would spread it out on special hardwood platforms, six feet long and eight to ten inches wide. The inside fibers of the bark were scraped with a piece of pearl shell or turtle rib. After the fibers were bleached dry in the sun and stripped into fine threads, the actual making of the cords began. The strands were rubbed together between the palms or against the thigh. This job was done by the women and it took long hard hours. When the cords were ready, the men would do the net making. A net was made to catch certain types of fish, or those closely related, so the dimensions were made accordingly. When the net was finished, it was dyed with the juice of the kukui bark. This was done several times to protect it against the salt water.

The hukilau was done as a community activity. This was usually done in a sandy bay area. The equipment used included a large net, two ropes of two or three hundred feet long with strips of ti leaves tied every twelve inches, and three or more canoes. One canoe was the fisherman's and carried the ropes two or three miles off shore. The ropes were tied at the two ends of the hukilau net. The two assisting canoes then took the ropes and paddled away from the center in opposite directions heading to shore. The head canoe would remain in the same place until the two canoes formed a semi-circle. The frightened fish would swim out but get caught as the net was pulled in. Everyone joined in by



pulling at the ropes and the fish were shared among all. Akule fishermen use similar methods today, although the nets are made of sūji and the weights are lead. The boats used have motors. The initial spotting of the school is done by airplane or spotters on high cliffs wearing Polaroid sunglasses. Those who help still get to share in the catch.

Torch fishing was frequently used in ancient Hawaii. Kukui nut kernels were strung on coconut midribs with a handle made of a bunch of ti leaves. The oily nuts produced a smoky, golden glow.

Today, kerosene hand torch and gasoline lanterns are used for night torch fishing. This type of fishing is done in shallow water along several miles of shoreline. The night air should be still, the tide low, the moon hidden and the water clear.

The spears used for torch fishing were made out of kauila, o'a, koa'i'e, uhiuhi and other hard woods. They were about six to seven feet long, slender and sharply pointed at one end. Modern torch fishermen use a three pronged metal spearhead on a wood or metal shaft.

Poisoning was another method used by ancient Hawaiians. Fish trapped in tide pools at low tide were sometimes caught with poison juices from the 'akia and 'auhuhu bushes. This didn't kill the fish but made them dizzy and easier to catch. The plants had no effect on humans. The leaves of these plants were pounded into bits and placed in small tapa cloths and stuffed in puka where the fish hide. This procedure was done quickly because the effect was soon lost. According to my interviews, plant poisons are infrequently used today. However, some people use Clorox or dynamite which is highly illegal. If caught, they face stiff fines and sometimes prison sentences. This shows a sharp contrast to the old days, for an ancient fisherman would never use methods such as these that permanently damage the tide pools.

There were many types of bait used in ancient Hawaii. There were two types



used, the live and dead bait. One of the live bait used was the iao, a slender, silvery fish about two inches long. These fish swim in large schools and are caught with dip nets. Opae or shrimps that are found in stream and ponds were used as well as the common black crabs.

A favorite bait of early Hawaiians was the ink bag of the octopus. They would remove the ink bag intact from its head and dry it under the shade for several days. Just before going fishing, they would take 1/2 teaspoonful of ink from the sac, wrap it in ti leaves and bake it for a few minutes until it was thick as molasses. Then finely grated coconut meat and a pinch of salt were added to the ink. A dab of this mixture was put on the hook. In the water this would send out a smell and attract the fish.

Other kinds of bait used were kukui and coconut meat baked together, shrimp dried and pounded, wana with its shell broken to expose meat, roasted sweet potatoes, raw ripe papaya, opihi, earthworms and puhi. Various kinds of limu were also used as bait.

Nehu, iao and akule were used as live bait. These fish were caught in the early mornings.

Today fishermen still use limu, black crabs, puhi, and octopus meat for bait. Live bait is still used, and the state is investigating ways to raise some types of bait for aku boats. There are some additions such as frozen squid or shrimps, and canned sardines.

Hooks of ancient Hawaiians varied in sizes, shapes and colors. Their hooks were made out of turtle shell, bones of animal and humans, woods and ivory from the whales. The bones of great warriors and fishermen were highly prized for making fish hooks. It was said to have the mana that the person had. A fish hook made from the bones of a person who had little hair on his body would be lucky. Such bones were supposed to be smooth and this would attract the fish. If a fisherman's hook broke while he was out fishing, he



knew that his wife had committed adultery when he was gone.

In choosing or making a hook the fisherman must determine the size of the mouth of the fish he wishes to catch. Then he must consider the sharpness of the point of the hook.

Modern fisherman do not make their own, but have a choice of many commercially made metal hooks. However, an individual fisherman may have his own personal method of lashing hooks to his line.

#### CONCLUSION

Today, anyone can become a fisherman and not go through any ceremonies and initiation requirements. Some of the methods used in old Hawaii are still used today but refined with modern equipment. Some people still use techniques taught by their kupuna. The Hawaiians used the kapu system as a plan of conserving the supply of marine animals for their future generations. Although the kapu system does not exist today, there are restrictions limiting the capture of certain species during certain months and making some areas kapu to fishing. There are game wardens employed by the state to protect and conserve marine life. Since they can't be around all the time, it is left mostly up to the individual. For example, one must put back a big, juicy, eggbearing lobster when caught in the off season. This shows the respect that the fisherman has for the sea, and a responsibility to preserve the life of the sea for future generations.



## GLOSSARY

AKIA - fish poison plant  
AKULE - mackerel  
ALII - nobility  
'AUHUU - fish poison plant  
'AUMAKUA - personal god, totem  
HOPUE - plant source of fiber  
HUKILAU - surround net fishing  
IAO - bait fish  
IPU - gourd, calabash  
KAHUNA - priest  
KANE - men  
KAPU - forbidden act or place  
KAUOLA - hard wood, a native tree  
KEIKI - children  
KOAI'E - hard wood, a native tree  
KUKUI - candlenut tree  
KU'ULAKAI - god of fishing  
LIMU - algae, seaweed  
MANA - power  
NEHU - bait fish  
O'A - hard wood, a native tree  
OLONA - plant source of fiber  
OPAE - fresh water shrimp  
OPIHI - limpet  
PIPIPI - periwinkles small snails found in spray zone  
PUHI - eel  
SUJI - synthetic cords



UHIUHI - hard wood, a native plant

WAHINE - women

WANA - sea urchin

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HANA FISHERMAN'S CLUB  
by Gizelle Matsuda, Hana High School

INTRODUCTION

In Hawaii, fishing is one of the most important and necessary industries for its people. There are many small fishing communities throughout the islands. One such community is Hana, which is located on the northeastern tip of Maui, with a population of 2,000 people. This small community has formed a unique public service organization, The Hana Fisherman's Club, which is operated by and for the people.

STATEMENT OF PROBLEM

Although I have known of the existence of the Club, I really had no concept of its history, organization, and the benefits it provided.

METHODS OF RESEARCH

There is very little written literature about the Club, so my resources were limited to personal interviews.

RESULTS OF RESEARCH

The history of the Hana Fisherman's Club goes back to the time of Lokahi Pacific in 1965. Lokahi, a non-profit organization was designed for the low-income families in Hana. It maintained close communication with its members, and worked together to benefit the community and meet its needs. Lokahi was funded by the government and provided training programs for its members which developed a greater understanding of the business world. These programs also provided an opportunity to make decisions affecting their future and the future of many low-income families of Hana. Lokahi also has scholarship funds available for the children of its members.

Projects that were beneficial to their community were planned in meetings and carried out by members. Fishing and Agriculture were the main projects that Hana



provided for its people. From the government, Lokahi was given three boats for fishing, diving gears, a surplus truck, the ice house and other facilities which were put to use by the members. "During its operation, it put a lot of members on their feet, on their own, not depending on the government".<sup>1</sup>

When Lokahi Pacific ceased operations in Hana in 1973, many of Lokahi's members were still interested in selling and buying fish and providing non-profit services to its members and the community. The result was the formation of a private club which they called The Hana Fisherman's Club. Although membership is unlimited, members pay dues and must be approved.

The purpose of the club is to provide public services to the community in the form of improvement projects and fund raising activities.

During the first couple of years, the club members raised money to purchase a boat, trailer, and other fishing equipment from Lokahi, as well as a new boat engine, a battery operated Beacon electronic beeper, and an ice-making machine.

All Club members participate in the various fund raising activities. The most profitable activity for the club is to buy and sell ocean products. Salt Salmon. Fresh Cod, and Butterfish are sold by the pound and sold at a lower price than in markets. Opihi is sold by the gallon. The club buys the fish and opihi from the seller, pays them cash and then sells it for a small profit. These products are distributed from Keanae to Kaupo by storing them in crushed ice coolers on trucks. The club once sold fish and opihi to other areas of Maui when they had a surplus truck which was purchased from Lokahi. It had originally been given to Lokahi by the government. With the loss of the truck, the buying and selling of fish and opihi to the other side of Maui ceased. As a result, the Club was limited to the community of Hana.

The selling of fish is done at the chill-room, known as the "ice house". Active members also participate in door to door selling. This money is then used to pay the

<sup>1</sup> Alfred Kahookele, Interview at his home. 5:30 P. M. December 29, 1979



lease on the ice house and operating expenses.

Another community service that the club provides is renting the ice house for storage. This service is an economic necessity for the Hana community. It primarily facilitates the three main occupations of Hana, which are fishing, agriculture, and hunting. Without the ice house these people would lose a tremendous amount of money. The ice house and its surrounding area is used by other organizations of the community such as the Canoe Club, the Hawaiians Baseball Club, and the many community luaus that take place in Hana throughout the year. One unusual use is float-building: each year one of the high school classes uses the area to build their elaborate float for the annual Aloha Week parade. A recent public service of the club was painting Hana Elementary School's playground equipment.

#### CONCLUSION

The Hana Fisherman's Club seems to serve many useful purposes in the community. An organization of this type would be useful in any similar community. In the future, perhaps this club can become a Fisherman's cooperative which could be even more useful and provide opportunities to qualify for government funding. As inflation continues, it becomes more important in Hawaii to attempt self sufficiency. An organization like this that helps agriculture and fishing could become very important in helping to maintain good standard of living necessary to Hawaii's people.

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BY LAWS  
HANA FISHERMAN'S CLUB

ARTICLE I: NAME

The name of this organization shall be The Hana Fisherman's Club.

ARTICLE II: OBJECT

The object of this club shall be to provide non-profit services to its members and the Hana community in general, specifically, in the use of facilities and equipment, selling and buying fish, and chill room use, with the approval of the membership.

ARTICLE III: MEMBERS

Section 1. There shall be no limit in numbers to the membership.

Section 2. Any adult resident of East Maui shall be eligible for membership, provided that such resident shall be screened and approved by the club membership. A person, so approved, shall be declared a member of the Club upon payment of initiation fee and dues for the first six months beginning with the month of acceptance.

Section 3. The initiation fee shall be \$5.00. The monthly dues shall be \$2.00 for males and \$1.00 for females. The Treasurer shall notify members who are three months in arrears. Those whose dues are not paid within one month of notification shall have their Club privileges withdrawn.

Section 4. Upon the recommendation of one member, seconded by another member, and by a three-fourths vote by the membership at any regular meeting, honorary membership can be conferred upon any adult who shall have rendered notable service to the club.

An honorary member shall have none of the obligations of membership in the Club,



but shall be entitled to all of the privileges except those of making motions, of voting, and of holding office. Honorary membership shall last for one year and may be extended indefinitely upon the recommendation and approval of the membership.

Section 5. All members of the Club shall be required to participate in all Club functions, if, at all possible. Regular meetings and fund raising projects are mandatory. Judgments and penalties shall be rendered by the membership on an individual basis.

#### ARTICLE IV: OFFICERS

Section 1. The officers of the Club shall be a President, a Vice-President, a Secretary, a Treasurer, and a Sergeant-at-Arms. These shall perform the duties prescribed by these bylaws.

Section 2. The officers shall be elected by ballot at the regular meeting in December and assume offices on January 1. All terms of office shall be of one years' duration.

Section 3. No member shall hold more than one office at a time, and no member shall be eligible to serve more than one consecutive term in the same office.

Section 4. The duties of the officers shall be as follows: The President shall preside at all meetings while overseeing and authorizing all the functions of the Club: the Vice-President shall assume the duties of the President when he is absent or resigns, post notices of meetings, and be a Club representative to the community and public; the Secretary shall record minutes of all regular and special meetings, and prepare all correspondences and notices: the Treasurer shall perform all of the general bookkeeping, prepare written monthly reports, receive and give receipts, authorize checks (with President), and provide reports at all regular meetings, the Sergeant-at-Arms shall keep order at all Club functions.

Section 5. The officers shall hold all keys to Club facilities and equipment. The officers shall be available to all members when locked facilities and equipment are requested for use.



## ARTICLE V: MEETINGS

Section 1. The regular meetings of the Club shall be held on the second Wednesday of each month unless otherwise ordered by the Club and/or the officers.

Section 2. Special meetings can be called by the President or by the request of five or more members.

Section 3. Eight members shall constitute a quorum for regular meetings.

Section 4. There shall be no drinking at/during regular meetings.

## ARTICLE VI: COMMITTEES

Section 1. A committee consisting of the President, the Treasurer, and three members of the Club in general, shall serve as an Audit Committee to check Club finances. This committee shall perform its duty before the regular meeting in December, or, before the new officers assume office in January,

Section 2. Special committees may be set up at any regular meeting in order to perform any special functions prescribed by the Club membership.

## ARTICLE VII: ICE HOUSE RENTAL

Section 1. The rental fee for the use of the ice house shall be \$5.00 a day for beef and \$3.00 a day for pork, unless otherwise ordered by the Club majority.

Section 2. Members shall receive credit for the first and last days of meat storage.

## ARTICLE VIII: AMENDMENT OF BYLAWS

These bylaws can be amended at any regular meeting of the Club majority vote, provided that the amendment has been introduced as New Business at the previous regular meeting.

Parliamentary authority used as reference:

Robert's Rules of Order, Newly Revised.







# Engineering







## ARTIFICIAL REEFS by Ian Haight, Parker School

The oceans cover seventy - one percent of the earth's surface. Throughout history, man has relied on the seas for food, recreation, and transportation. Here in Hawaii, we are surrounded by the ocean. Tremendous opportunity lies in the fields of energy, food resources, transportation, and recreation. In the past, certainly these things have been important, but with all these impending crisis- food shortages and dwindling energy supplies- man has become increasingly aware of the ocean environment.

Yet the ocean too, despite its vastness, is a fragile and vulnerable kingdom. In Hawaii, much of our activities are concentrated in the sub littoral and littoral zones and are particularly dependant on the living coral reefs. How important is a coral reef? One coral head provides food and shelter to a millenia of marine organisms. Fish dart in and out of this protective maze, constructed of hard calcium carbonate skeletons- the remains<sup>of</sup> tiny animals called polyps. An entire reef may be made up of billions of such creatures. Almost all corals grow at agonizingly slow rates, about three eighths of an inch or so per year. Thus, the largest coral trees are very old. Growth is determined by many factors which include temperature, food supply, ocean currents, and in the case of Hawaiian reefs, the availability of light. Areas exposed to wave action will erode. Pollution and runoff of sediments will smother reefs and hamper growth. Even reef areas unaffected by pollution or other stresses show signs of decline.



Obviously then, the rejuvenation period of corals destroyed by pollution and wear is very slow. In Hawaii, where evidence indicates that growth is slower than elsewhere, there is concern by people whose lives revolve about the oceans.

Yet, there are alternatives: we can sit back and watch the coral reefs die or provide an artificial means of support. The destruction of our reefs would take with them the marine ecosystems whose activities stem from the coral environment. With the disappearance of reefs and reef communities go such past-times as fishing- which to many is a form of livelihood- skin and scuba diving, and, perhaps the most rapidly growing sport of surfing.

Marine specialists as well as some surfers are showing a driving concern for are dwindling reefs. They suggest an alternative type of reef - a man-made reef. Though little research of this possibility has been made in the past, people's attention is turning more and more to the study of artificial reefs.

The history of artificial reefs is a short one. There have been many attempts in building artificial reefs for surfing purposes, but there outcome has always been the same, unsuccessful. This can be attributed to the fact that artificial reefs have been built only by surfers without the help of some credible organization. They were also built without much funding. One such case of establishing an artificial reef was by Mr. Ron Drummond who talked the Army Corps of Engineers into barging dredged material from the Dana Point Harbor in California over to Capo Reef, about one quarter mile away, and dump it. Without stabilizing the material over the reef, the littoral drift snatched it up. The newly created



waves lasted only a few weeks. It was just about this time that Rick Grigg published his article on the structure and possibilities of a well made surfing reef. Grigg's design was based on a natural reef. This prompted the beginning of another project which was headed by Hoppy Swarts. This time the WSA (Western Surfing Association) supported the project. The plan was to lay some 120 specially designed sandbags on the ocean floor. The bags provided by a Florida/California company known as Erosion Control Systems, could be pumped full of sand while in place on the sea floor. The bags were layed 150 feet from shore, slowly building back toward shore in the shape of an isosceles triangle. Depth ranged between 14 and 7 feet. Inconsistencies in the design of this man-made reef plus the fact that it was placed in too deep water lead to the impotency of the reef. The sandbags raised the bottom depth only about 18 to 24 inches. This gradual slope over a distance of 100 feet focused the waves on the reef, but the swells failed to break on small days. The reef did not provide enough of a shallow, sudden disturbance to cause the waves to jump and break. Failure was also attributed to the area's highly unstable sand bottom. After awhile, the bags sunk into the ocean bottom such as the way your feet do when you stand in the sand. The reef would have been much more successful had the WSA had enough money to improve the reef's design, and, as such, its effectiveness. Nevertheless, efforts in artificial reef construction should be continued.

Surfing spots today are overwhelmingly crowded. Popularity in the sport has been growing at an enormous rate. The young battle with the old for even the smallest of waves. Injuries are becoming more frequent and unfortunately more



severe. And all this can be attributed to the tremendous amount of boards now seen at almost every surfing spot. Also we have outgrown the days of the ten foot tankers. Boards have become shorter and sharper. Many boards have two to three skegs, all very sharp! Still there are times when longboards compete with the shortboards creating many a problem. Longboarders usually sit farther outside than the shortboarders. Shortboard surfers are therefore at a disadvantage since surfers using the longboards can catch the waves farther out. While jockeying for position, conflicts may occur. And, too, there is always competition between the surfers using the small boards. Obviously, there is a problem. Too much traffic in the water like too much cars on our highways, increases the likelihood of accidents. The only solution would be to create more surfing reefs.

The advantages of such a reef are numerous. The crowd factor would thin out, thus making surfing safer. A new reef would also prevent beach erosion by causing the waves to break thereby dissipating their erosive energy. This might be the greatest attribute of such a reef. Beach frontage and sand are extremely valuable for they support a billion dollar recreation and tourist economy. The ecosystem of the area where the new reef has been established would also benefit. Coral would have something concrete, something stable, to attach itself to. A natural reef might thus be established. An artificial reef could provide protection for many reef dwelling creatures. Fish and other inhabitants can hide within the structure. Eventually, this artificial reef system would be as supportive as a natural coral reef, producing food and



shelter for many marine organisms. Fishing interests would also profit: the new reef would attract fish from other areas, thus increasing the productivity of fishing.

A new project is planned in California. Two reefs will be built in El Segundo. Together Southern California Edison and Standard Oil of California have pledged \$400,000 to the project. They share the same reason for helping this project- to modify beach erosion. There is virtually no beach left in the El Segundo area. Introducing artificial reefs would dissipate wave energy, greatly reducing their erosive power. These reefs, according to plan, will be made of granite boulders weighing 40 tons each and will be 250 feet wide and 550 feet long. Hopefully, this effort will prove successful and not follow the path of previous projects. With all our technological genius, it's about time we expanded surfing instead of destroying it, one break at a time.

Perhaps in the near future, we can expect to see such developments here in Hawaii. For reef conservation, preserving and maintaining the marine ecosystem, an artificial reef system can be placed in such areas as Kaneohe Bay where man's carelessness and thoughtless efforts have been extremely destructive. Surfers, however, may not wish to attack this spot since Kaneohe is well known for its local shark population. Hawaii too has its possibilities. A reef could be established at Hapuna Beach transforming the closeout shorebreak into a perfect wave. With an expansion of surfing breaks, the sport of surfing is naturally going to progress.



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OCEAN LAB UNDERWATER HABITAT  
by Paul Panilo, Honoka'a High School

ABSTRACT

The earth may one day become so thickly populated that men will have to turn to the ocean to find a place to live.

This report is on a structure which can be built underwater. A structure that enables men to study the environment and a way of life on the bottom of the sea.



## INTRODUCTION

There are ways in which man can explore the ocean bottom. One way is that of the diver in the old traditional diving suit that can safely reach depths of about 50 to 600 feet. His movements are quite restricted and he depends on a surface source for air.

For unlimited freedom of movement, a diver may use an aqualung or scuba (self-contained under breathing apparatus). The diver, instead of depending upon surface source for air, uses tanks of compressed air which are strapped to his back. Divers with this apparatus have made descents to depths of more than 300 feet. The range of this apparatus limits the oceanographer to depths of between 200 and 250 feet.

In 1930, Dr. William Beebe used a bathysphere (Fig 1) to study and photograph deep sea life. This device was a hollow heavy ball made to resist the pressure of the ocean bottom. This device could be lowered from a ship on a very long cable. This device put the deeper depths within mans reach but maneuverability was severely restricted.

Later in 1948, a Swiss professor, Dr. Auguste Picard, designed a very successful depth ship called a bathyscaphe. The bathyscaphe was free to move up and down under its own power. (Fig 1) It was an improvement over the bathysphere but still lacked maneuverability.

Now let us discuss men trying to live underwater for long periods of time. In this report I will describe my proposal of an underwater laboratory. Although this idea may seem very impractical at this time, it may some day be achieved.....



Fig. 1

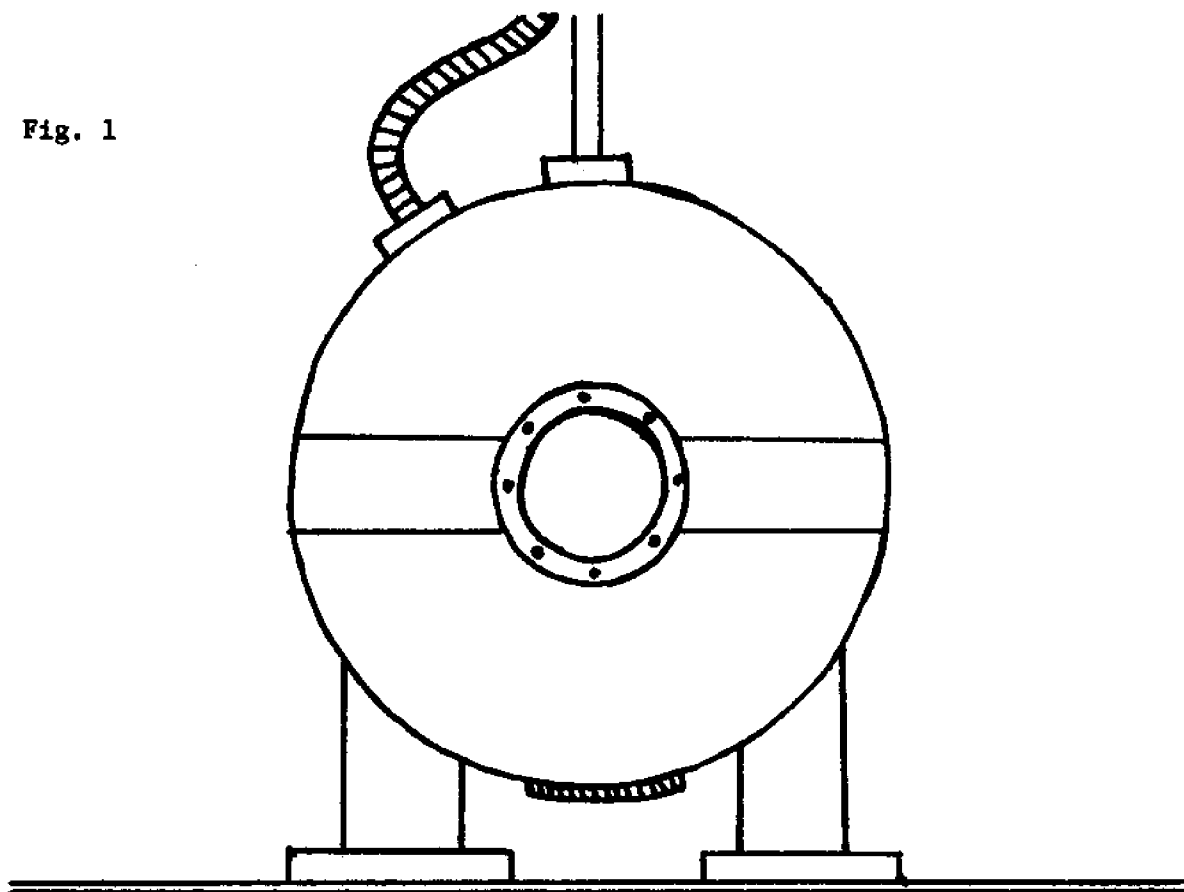
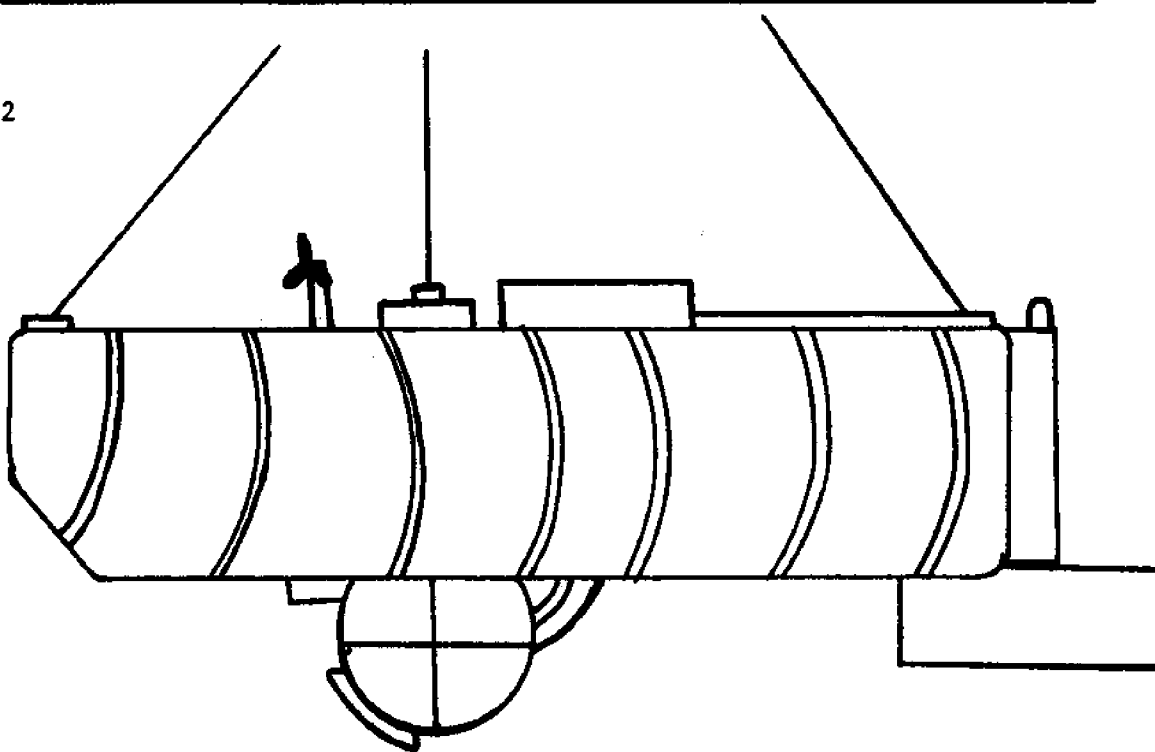


Fig. 2



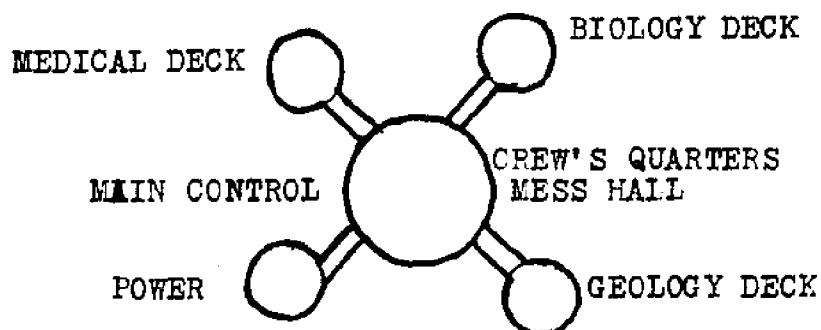


A brief description of this habitat follows: The structure is shaped like a cross. (Fig 3) The center structure is the main section. In this section are the controls, main air supply, power units along with the crews quarters and mess hall. Then from the middle section there are four corridors leading to sections for geology, biology, medicine and power. Now we describe each individually.

This design has five major structures. Each one with its own emergency air and power supply in case the main supply is cut off for some reason.

DECK 1 Control Room-This deck is the "brains" of the entire complex. In this room there are the control computers which store all the information that is gathered from the ocean floor and surrounding environment. Then we have the communications area to keep the habitat in contact with ships in the area. With an intercom unit for intrahabitat communications (contact with the rest of the complex.) We also have television monitors to monitor the progress or the dangers in the complex and surrounding environment. (Fig 4) The engineering and environment systems are to control the electricity and air usage.

FIG.3





DECK 2 Crews Quarters-This deck is designed to accomodate ten crew members. There are six rooms, five of which will accomodate the ten crew members and the sixth will be a bathroom facility. This deck also has the emergency air and battery power for decks 1 and 2. (Fig 5)

DECK 3 Mess Hall-On this deck you have the main air storage and the food preparation and storage compartments. The kitchen area is built to accomodate eight crew persons at any one time. (Fig 6) From this deck there are four corridors leading to the power, geology, medicine, and biology sections also referred to as decks.

FIG. 4  
MAIN CONTROL ROOM

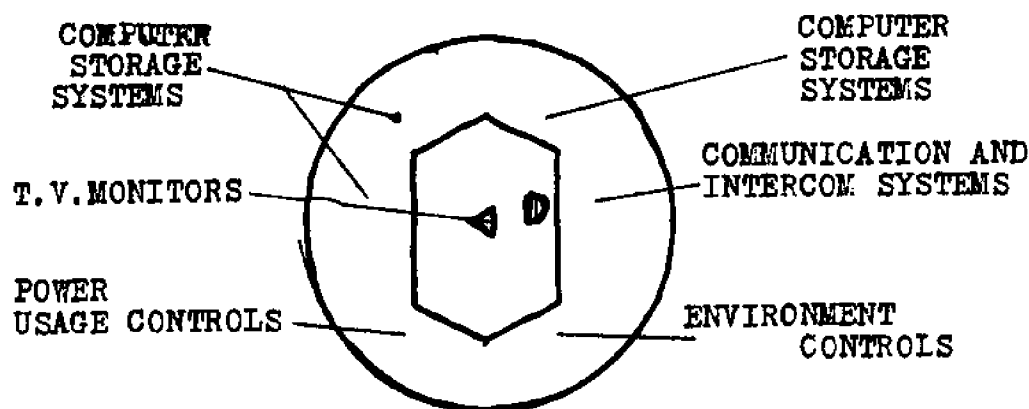


FIG. 5  
CREW'S QUARTERS

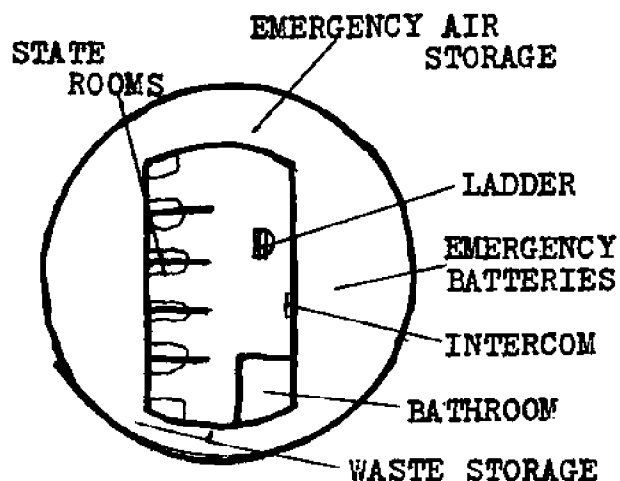
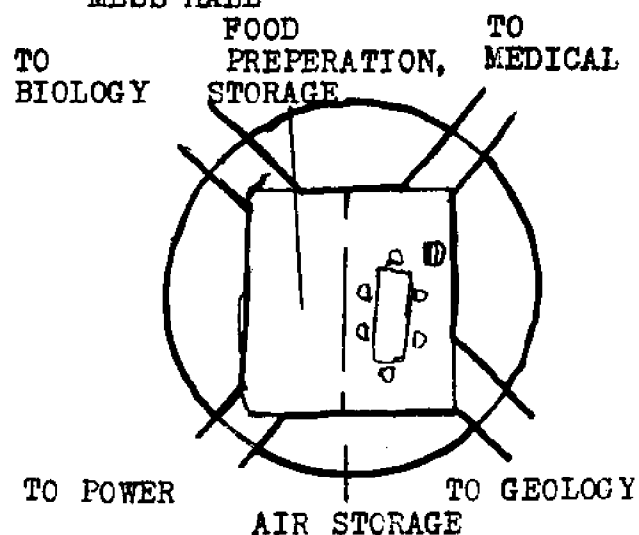
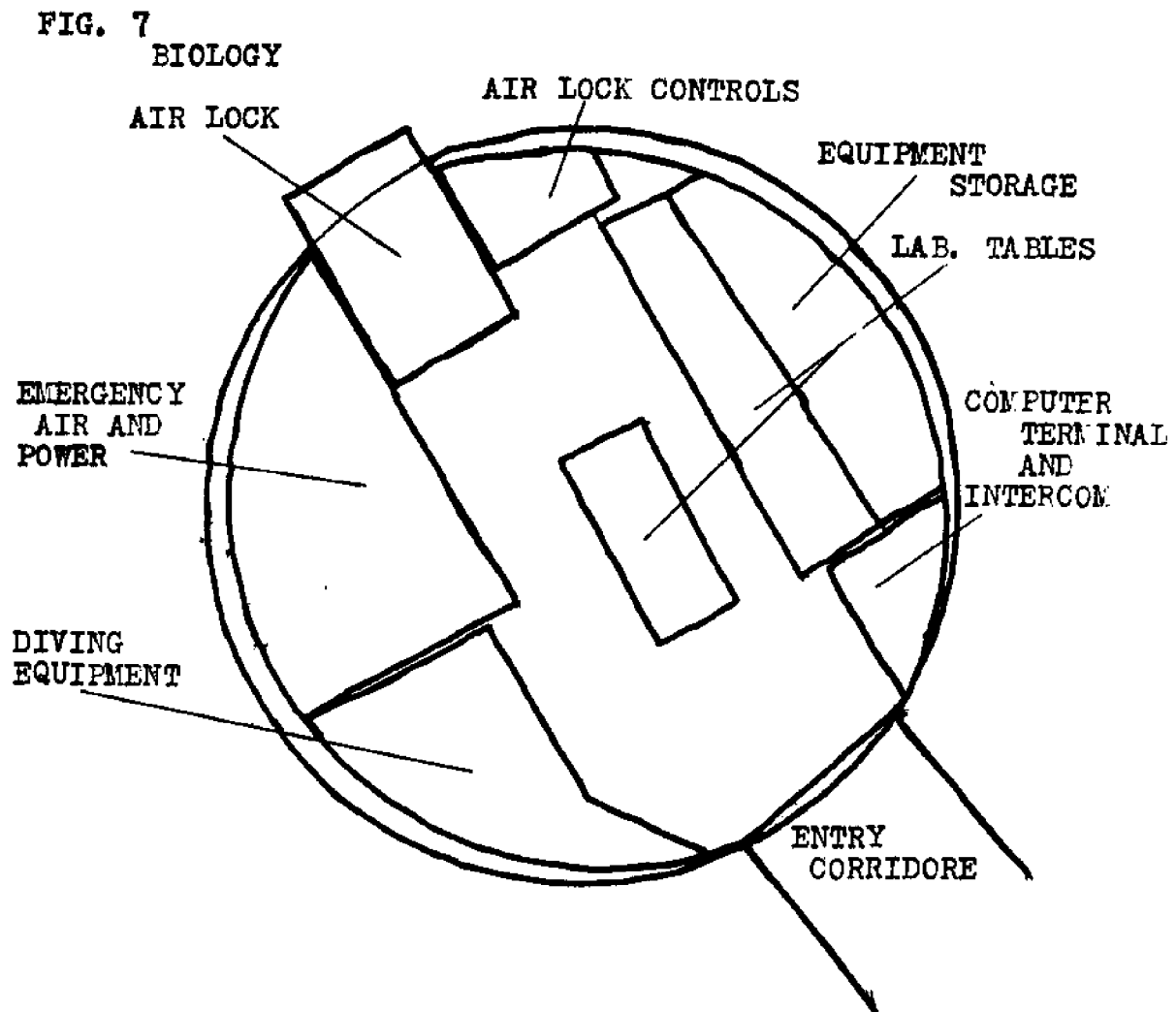


FIG. 6  
MESS HALL





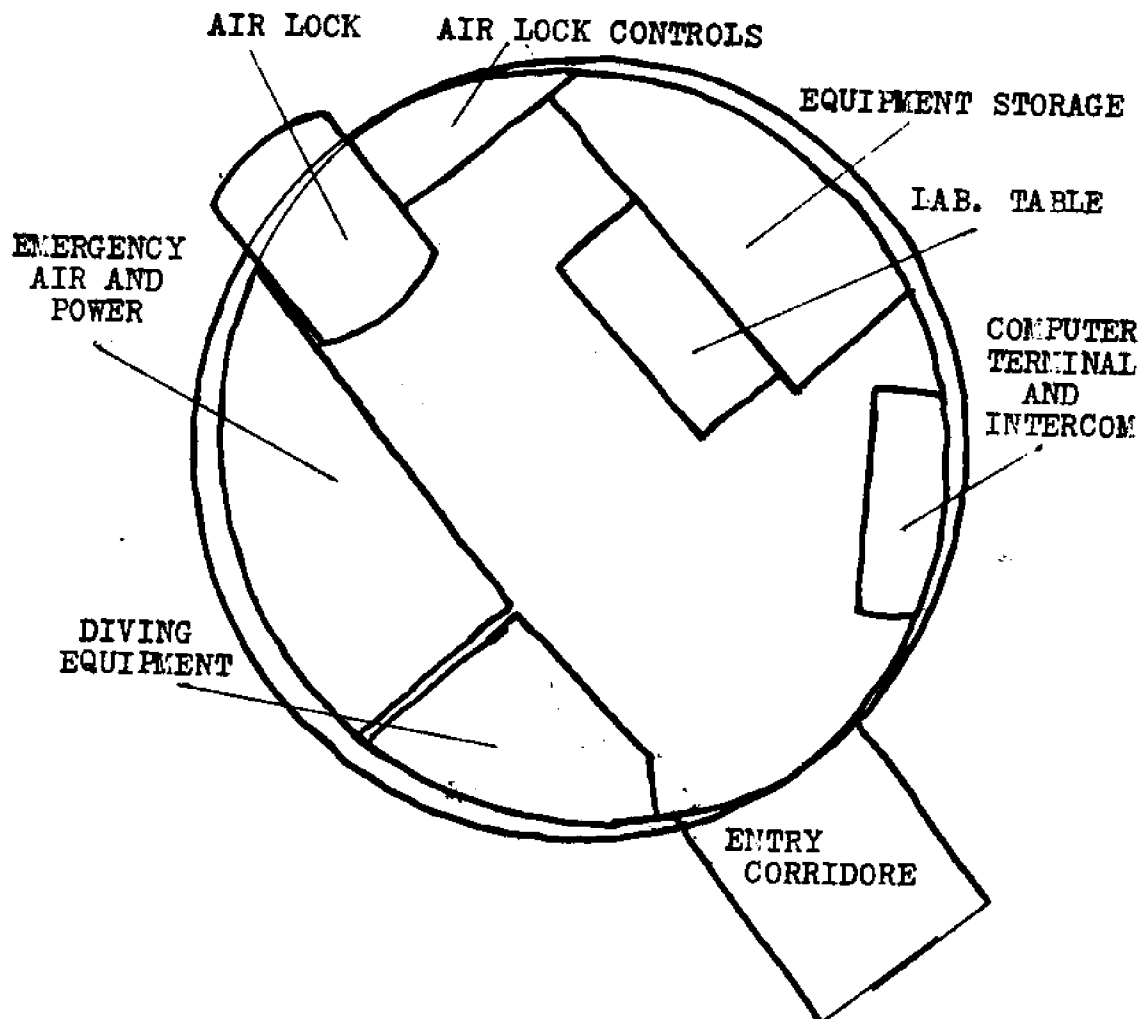
DECK 4 Biology-On this deck you would find almost all the equipment and materials that you would find in a biology laboratory but with a few exceptions, such as an air lock and computer terminal. The computer terminal is for storing data for this section and is connected to the main computer. Also located on this deck are emergency air and battery units. From this structure we have six probes, three are floating upward, and three lying on the bottom. The probes will provide data on temperature, pressure, and salinity of the water and other environmental factors. (Fig 7)





DECK 5 Geology-We have most of the equipment that you would find in an ordinary geology laboratory. In addition, the air lock, air lock controls, computer terminal, and the 24 hour emergency air and battery supply units are also located here. Probes from this structure test temperature and record ground movements and other geological conditions.(F19,8A)

FIG. 8A  
GEOLOGY





DECK 6 Power Source-The power source we plan to use will be geothermal. (Fig 9) First drill two holes in the ocean bottom. (a) One hole will be at a short taper. Water will be pumped down to a point one and one fourth miles down to the hot rocks below. The water will then turn to steam and will come up the vertical pipe and turn a turbine. This in turn will turn a generator to generate electricity to power the laboratory. The heated steam will also be used to heat the complex.

DECK 7 Medical-This deck comes with two beds, medical storage areas, two decompression chambers with controls. (Fig. 8) The air and battery units stored in this area are good for 48 hours, unlike the other units which are only good for a 24 hour period.

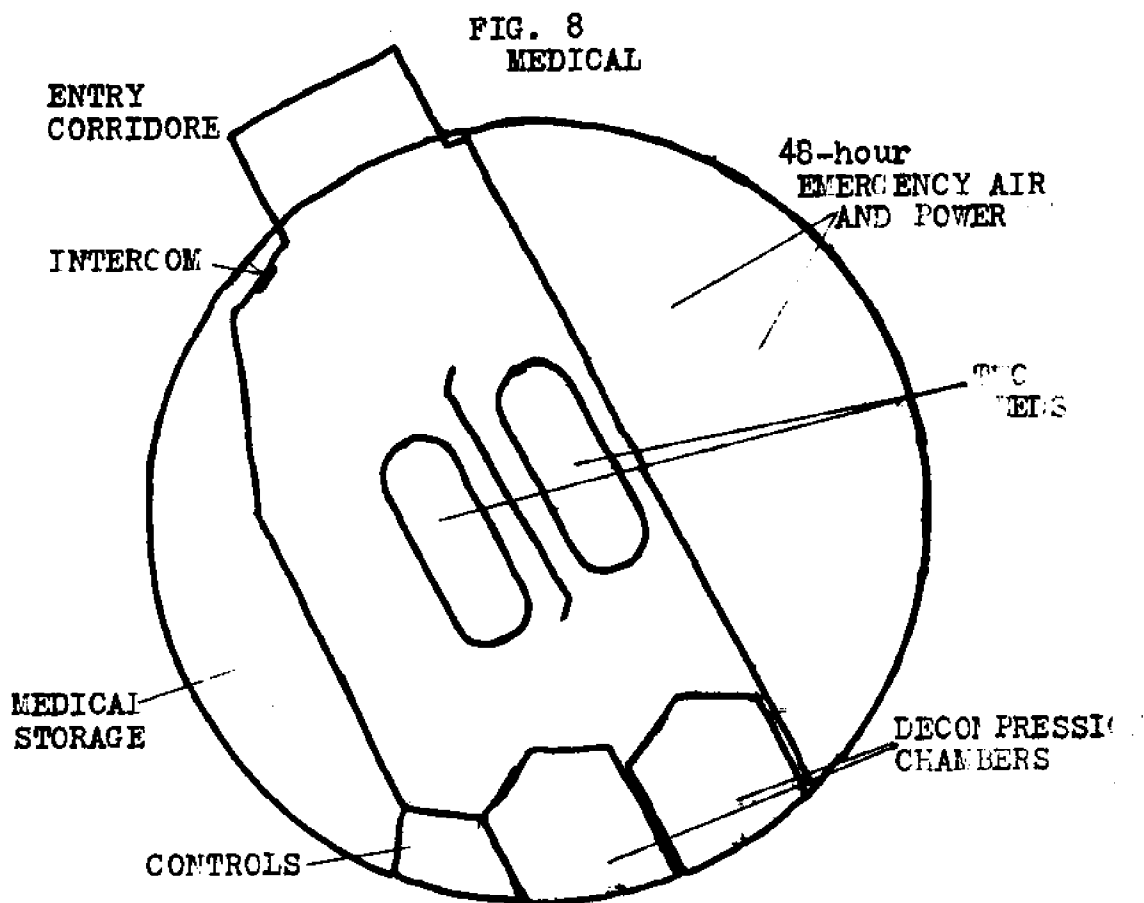
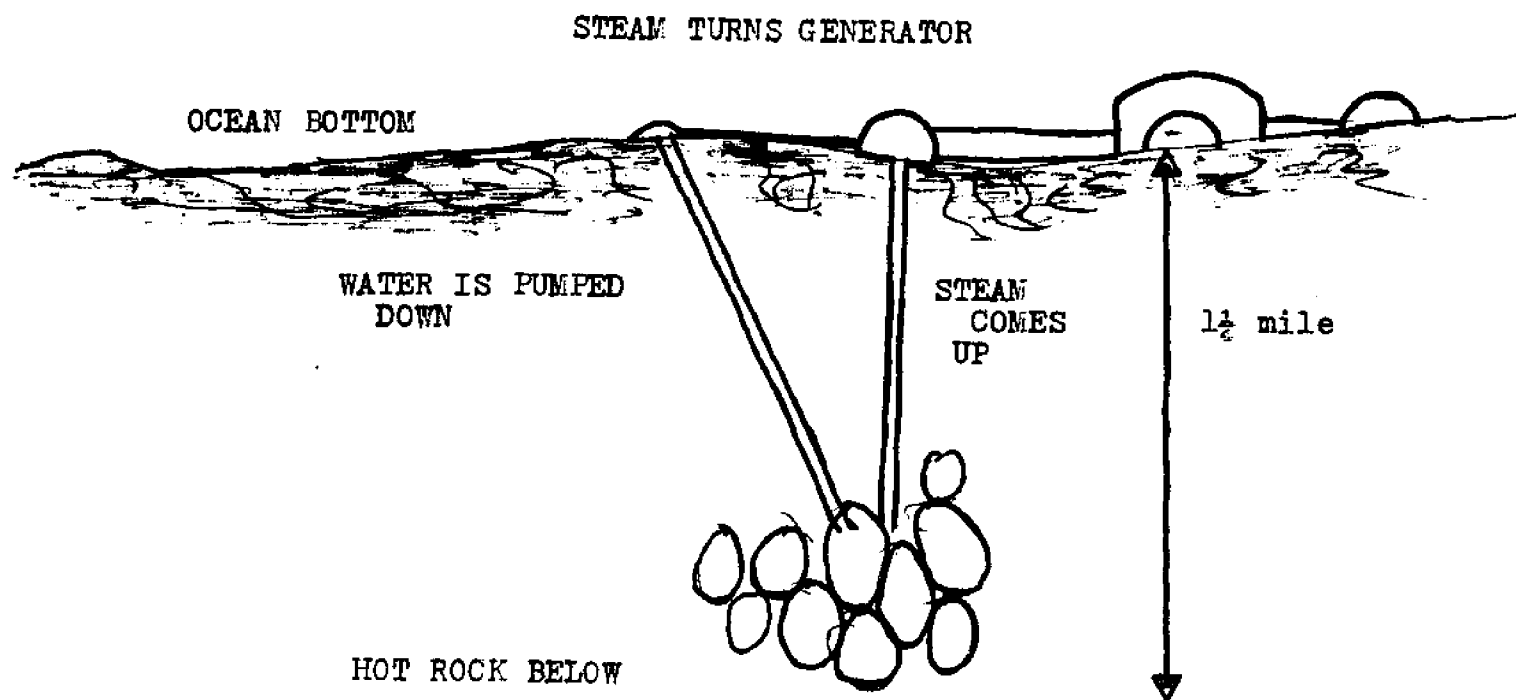
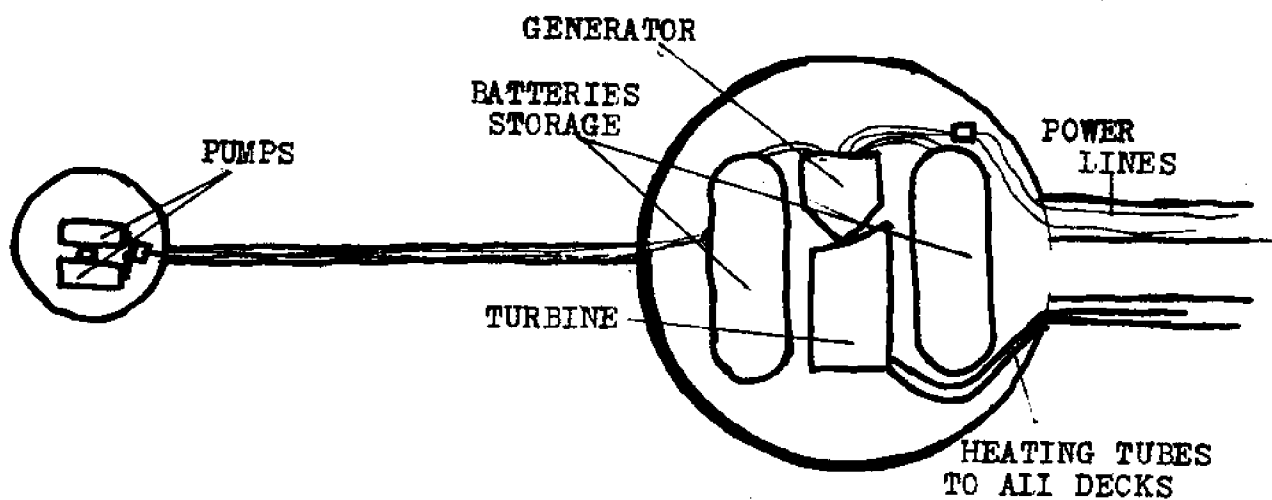




FIG. 9 Power Source





As you know this is still just an idea and it may never work. But with man's increasing knowledge of the environment that surrounds him, he may develop an apparatus which will take him to all the areas of the environment, and be able to survive, from the top of the world to the bottom of the sea.

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( Sky Lab )                      Vol. 146 No. 4    October 1974



HAWAII'S FUTURE CITY  
by Christine Miranda and Belinda Gauvreau, Pearl City High School

ABSTRACT

Life on Earth first developed in the sea. And in the future, man will go back to the sea: to live, to mine, to farm.

--Kenneth Goldstein

The water on our planet covers 140,000,000 square miles, or 71% of the earth's surface. That leaves only 29% covered by land for people to live on. As each year passes, the earth's population increases. More living space must be found.

In our paper, we are going to discuss an alternate living environment; the general concept and idea of the floating city.



## INTRODUCTION

Man has always realized that water is the key to life. Since the early ages, life has centered around springs, streams, rivers, and the ocean. Now, man can go a step further. Floating cities make it possible for him to live on the ocean.

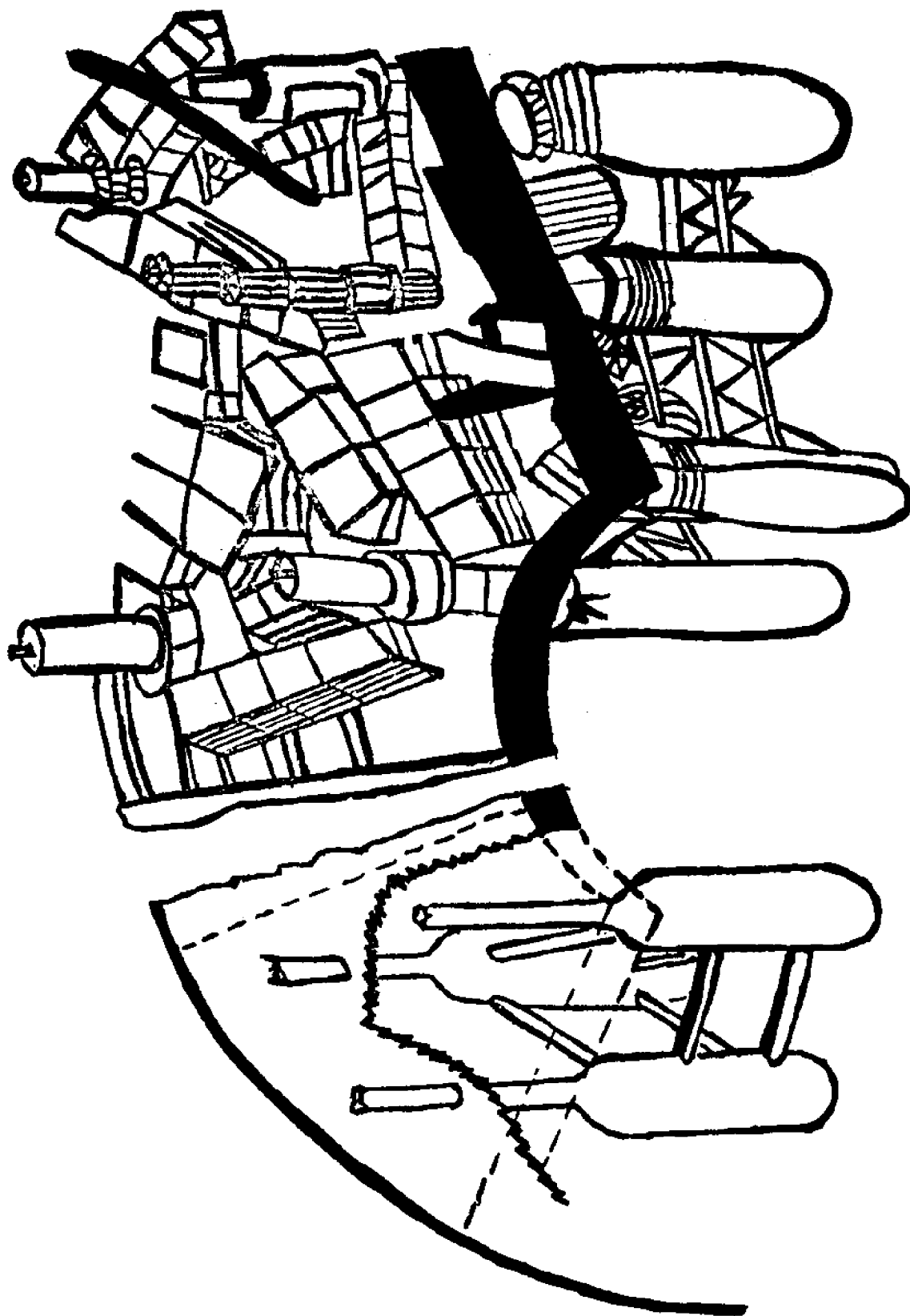
For years, mystery writers had a romantic image of a city on the ocean. It was a place of refuge, hidden away in some remote area of the world. The ancient Aztecs utilized floatation devices to support the famous Floating Gardens of Xochimilco, located a little south of Mexico City. Since a majority of the surrounding area was a swamp, these "floating islands" were built to give them much needed land to raise vegetables. Science-fiction writers had a more practical image for a floating city. They thought of it as a solution to the problem of overpopulation, and in fact, it may well be.

## THE CITY

The design of the floating city will be round with inner and outer rings. These rings will consist of approximately thirty independent, sturdy, removable sections. Each of the sections, or modules, will have a different function. These modules will be connected together rigidly to form the city. Each can be disconnected for repair or renovation. The modules are supported by three or four buoyancy chambers. The modules, topped by a structural column, will form the core of the multi-level superstructure.

The city will house a variety of recreational, commercial, industrial, domestic, and public activities. These will be linked with Oahu by a broad range of communications and transportation services. The commercial, industrial, and public services would account for available space in the underwater buoyancy chambers. Fuel and water are stored on the bottom level of





FLOATING CITY MODULE



the city. In the lower levels of the buoyancy chambers are the facilities for the treatment of sewage and variable stabilizing tanks. The middle levels contain the generator, cooling system, and desalination facilities. Also included in the middle level of the buoyancy chambers are cold storage, repair shops, and warehouses, along with stores and offices. The highest level will house apartments, condominiums, restaurants, and assembly halls.

The main deck structure is located in the highest level of the buoyancy chambers. The structure contains transportation terminals, and recreational and shopping facilities.

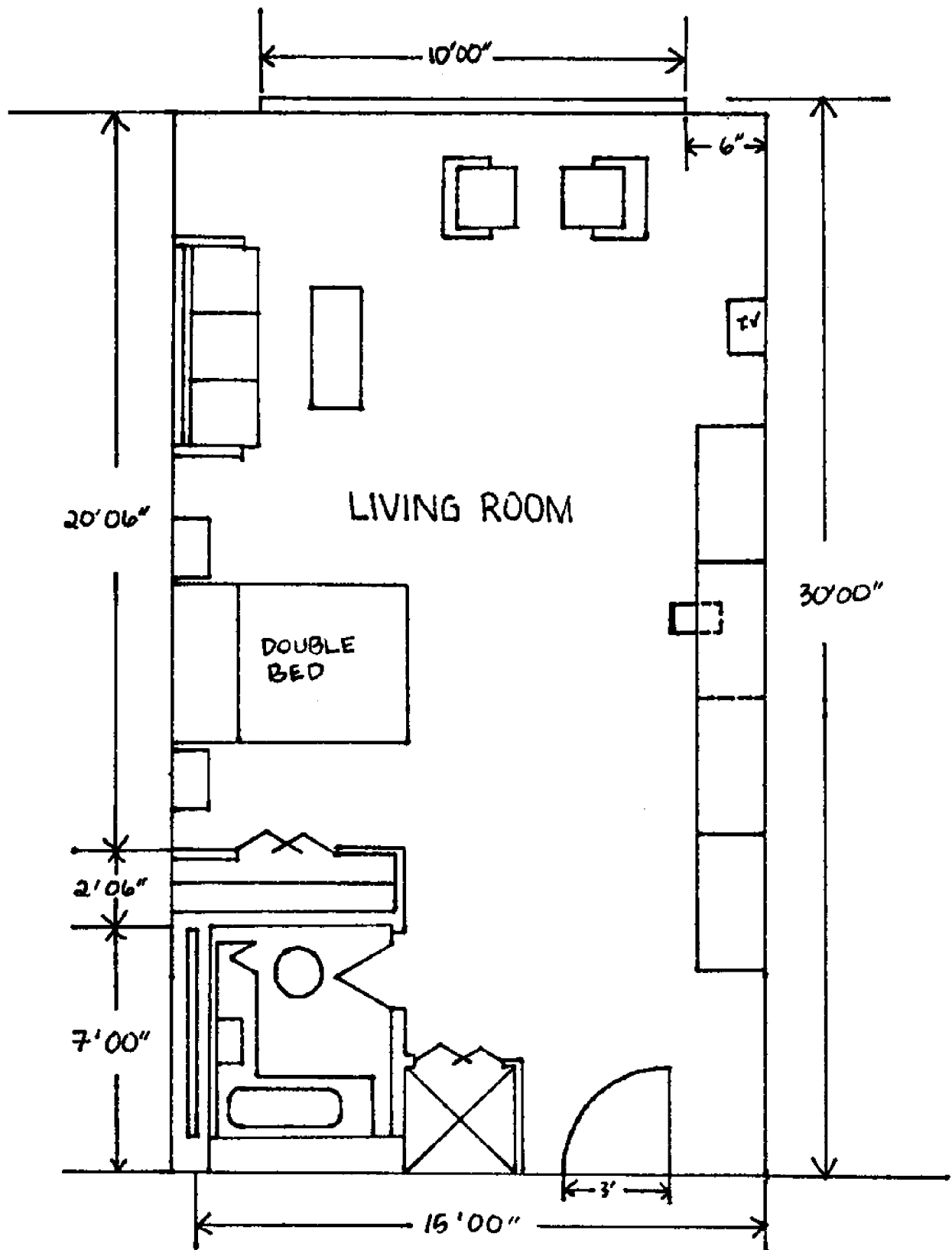
The weather surface of the main deck area will be a park. Finally, the city will have an abundance of living area, either apartments, condominiums, or hotel rooms.

The projected population of a floating urban center is 10,000 to 15,000. It is envisioned approximately five miles offshore Honolulu. This places it in an area close to a major harbor, airport, and urban and industrial area. Although this may, at the moment, seem to be an ideal location, it does not restrict floating cities from being built at other locations. Other proposed sites are Kawaihae Harbor, Ahukini Landing, Port Allen, Kaunapali Harbor, Maialaea Bay, Keehi Lagoon area, and Barber's Point.

Transportation from one place to another is especially important in a floating city because of its isolation from the "main" land. The external modes of transportation consist of submersibles, semisubmersibles, hydrofoils, PRT vehicles, private crafts, and helicopters. These types of crafts enable people to travel to and from the city.

An example of a submersible craft is a submarine, where the whole craft is underwater. A semisubmersible is similar to a submersible, but it has only its hull submerged and is conventionally propelled. Its stability is partially dependent on high speed and heading towards the waves. A hydrofoil,





TYPICAL ROOM IN A FLOATING CITY



however, must be propelled at high speed on the surface of the water. The jet turbine engine pumps the water and that, in turn, enables the craft to travel above water.

An efficient type of transportation for the floating city would be the Personal Rapid Transit System (PRT). A PRT vehicle runs along a fixed guideway and provides a rapid and safe ride. There are two types of PRT vehicles, both of which are automatically controlled by computer. One is the bottom-supported PRT system. This system rides along the guideways on either wheels or an air cushion. Another type is the overhead PRT system. It is connected to the rail by a gimbaled joint. The gimbaled joint and dynamic wind force prevents the system from free swinging.

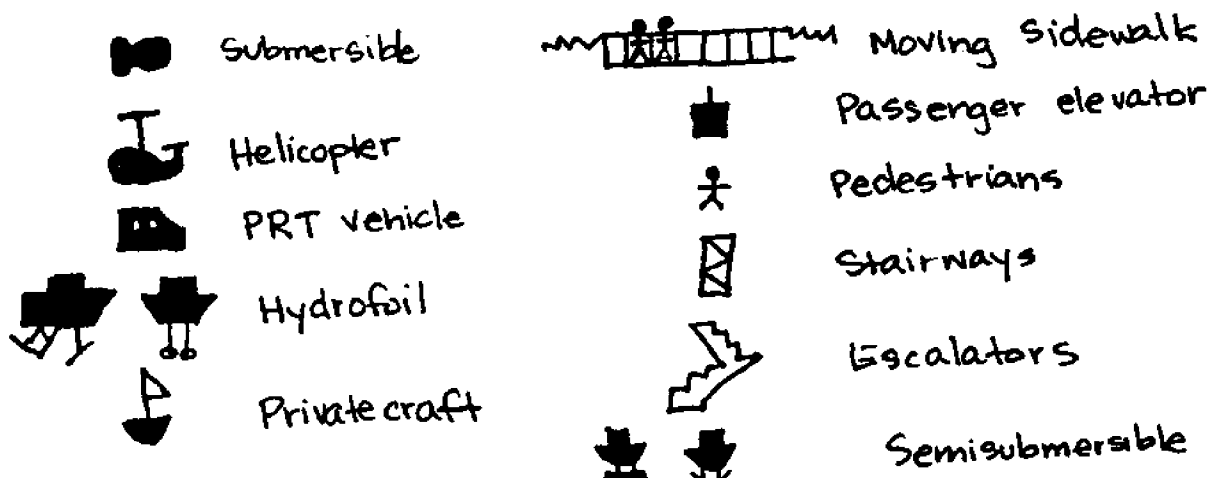
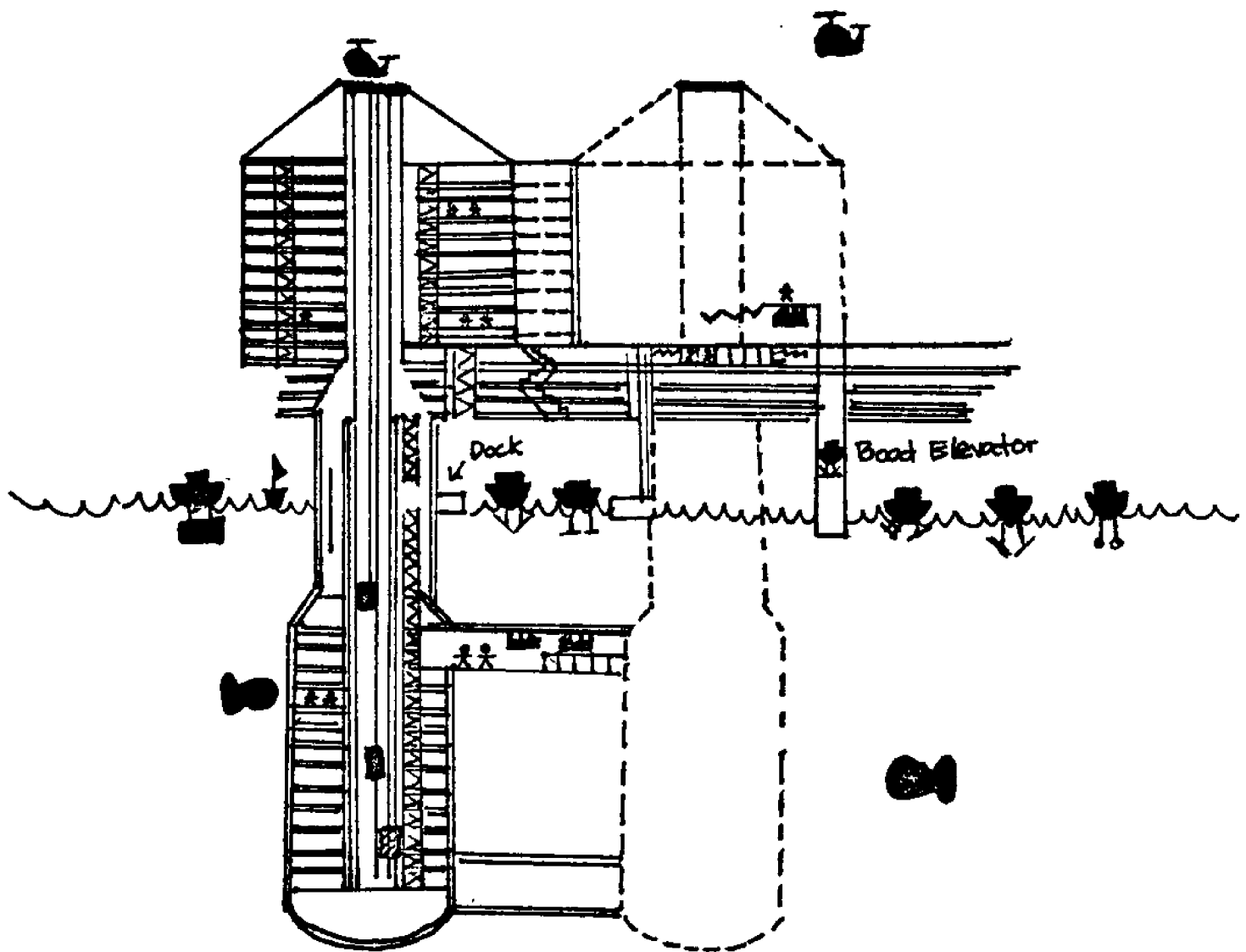
There are also, for commuting and pleasure, private vehicles. For air transportation there are helicopters. Helicopters transport items and people to and from the shore in a faster manner.

The floating city will have various docks and ports for these crafts. The main deck on the highest level of the city will have landing areas for the helicopters.

Transportation within the city is relatively simple. The city is built as a three dimensional structure. Since there are not any long horizontal distances to travel, the need for cars is diminished. All that are needed are moving and traditional sidewalks, passenger elevators, stairways, and escalators.

Many people have expressed their reluctance to live in a city on the ocean. They are afraid that the city will not be able to hold up in high seas. Research with semisubmersible units has demonstrated that a floating city can be kept stable without mooring. The idea behind this is that the





MODES OF TRANSPORTATION



major portion of the submersible is located in deep water, below the influence of the waves. In fact, a floating city may at times be safer than cities on land. The impact of an earthquake is substantially less at sea than on land.

The floating city shows great promise in the future. It can help solve many of the present, land-based city's problems, such as: pollution, transportation, overpopulation, and inefficient use of land. Its greatest benefit is in its restricted limits and three dimensional structure which makes distances to transport people and goods shorter. With these shorter distances and three level space area, the need for cars is diminished. With less cars and traffic, the city will have fewer pollution problems and the people will find traveling easier.

Who knows? Maybe within the next two decades Hawaii may have its own floating city, and you may be living on it!

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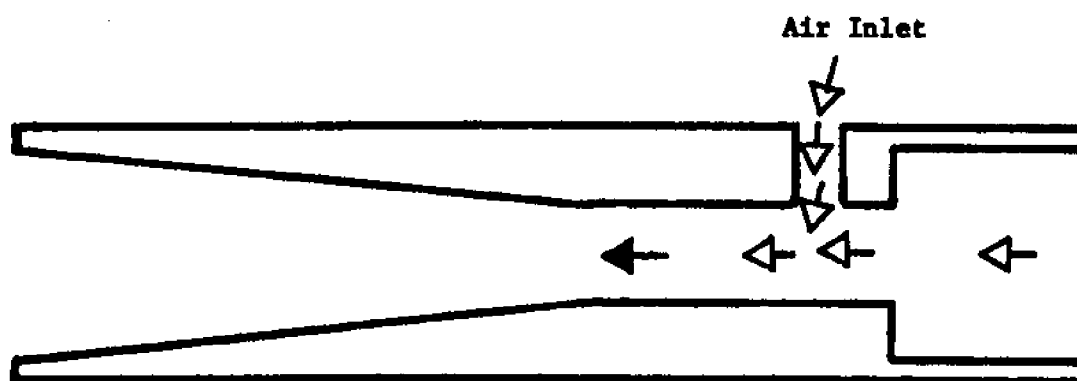
A SYSTEMS APPROACH TO DO<sub>2</sub> BOOSTING VENTURI UTILIZATION  
by John Hong, Moanalua High School

ABSTRACT:

The previous year's research has shown that the most cost/effective method of boosting the DO<sub>2</sub> level of the seawater at the Waikiki Aquarium is with the installation of venturi inspirators on the main seawater feed lines. The effect of these large venturis would be enhanced with the use of smaller venturis intended for a lower flow rate. To reduce cost, these venturis will be fabricated at the Aquarium with polyester resin. The production and installation of these venturi inspirators is the topic of this report.



This paper is a continuation of the research undertaken last year concerning the upgrading of the seawater delivery system at the Waikiki Aquarium. (see last year's proceedings) Last year, a small venturi device was tested which produced a 70% increase in the  $DO_2$  level. Unfortunately, the time, labor, and expense of equipping all the tanks at the Aquarium with this device was prohibitive. As a result only a few 'high priority' tanks have been so equipped. These venturis have proven to be effective only at high flow rates. At lower flow rates the venturi effect is weaker and there is less air entrainment. A systems approach would call for the addition of a smaller low range venturi device and a larger main line venturi device.



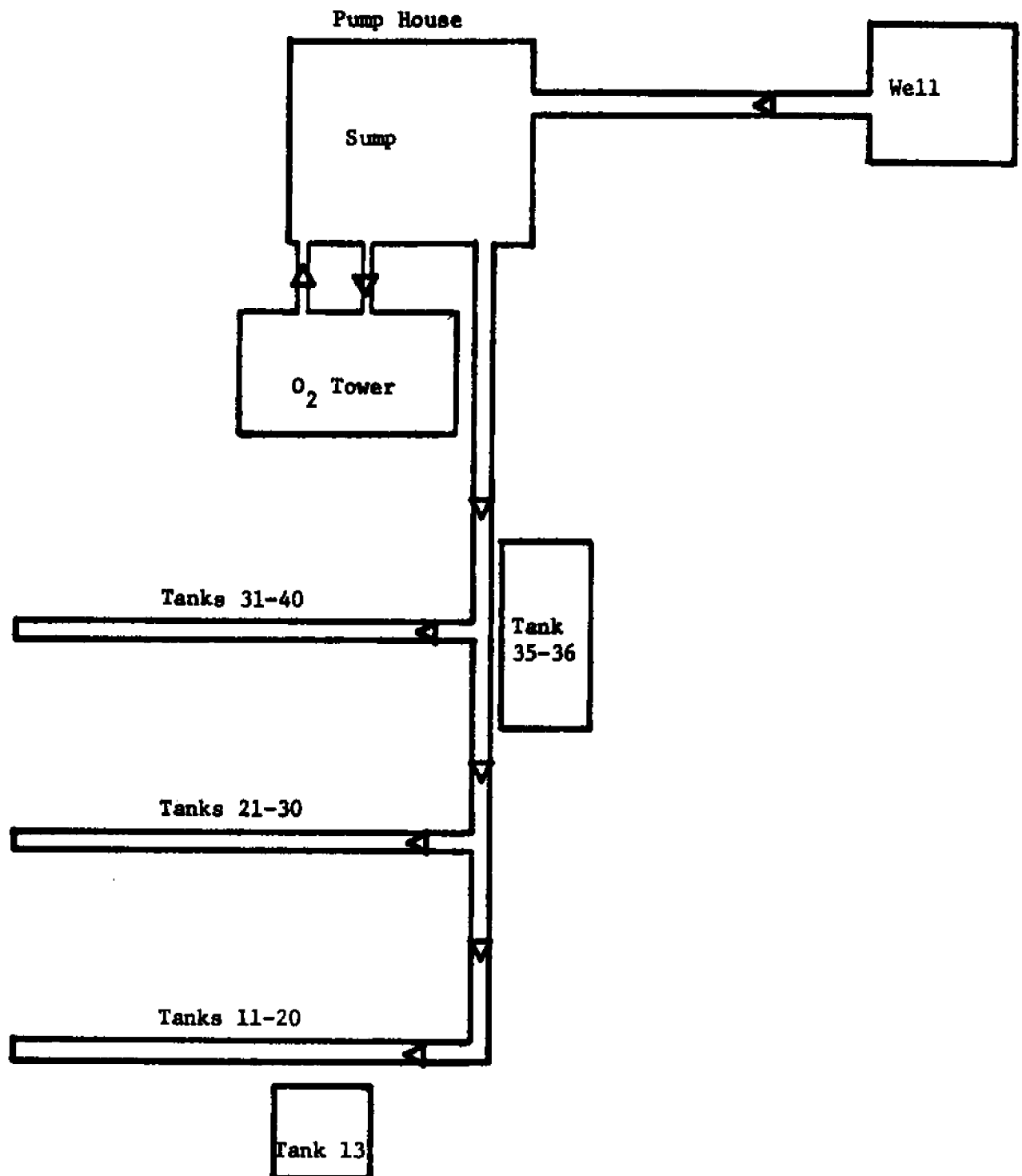
Cross Section of Venturi Inspirator<sup>1</sup>  
(Full Size)

The venturi inspirator is capable of producing an extremely high concentration of dissolved oxygen ( $DO_2$ ). Water flowing through the inspirator draws air in through the air inlet. The air and water are mixed together and sprayed out.



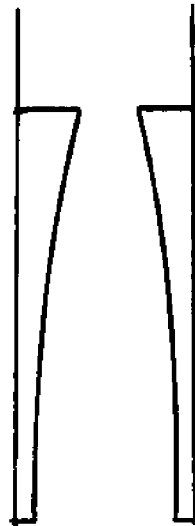
# The Waikiki Aquarium Sea Water System

Ocean

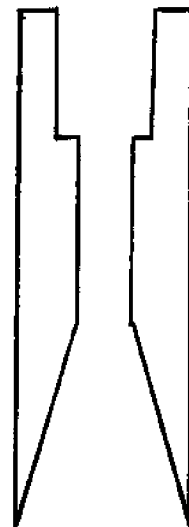




The prototype venturi was machined from a solid plastic cylinder. This method has been quite expensive. A less expensive method would be to mold venturis with polyester resin. Although the initial cost of machining the mold would be comparable to the cost of one machined venturi, a definite savings would be realized with additional molded venturis. A venturi was fabricated for test purposes with this method. A 2" pipe was placed over a tapered wooden cylinder (a baseball bat), polyester resin was then poured around the mold and allowed to cure. The bat was then pushed out and an air inlet drilled. When tested, this venturi increased the  $DO_2$  level from 3.8 ppm to 5.4 ppm, a 40% increase. This result is relatively low when compared to the 70% increase obtained with the prototype. It must be noted that the baseball bat did not closely match the configuration of the prototype. A mold which closely follows the original configuration should be expected to produce a higher  $DO_2$  level.



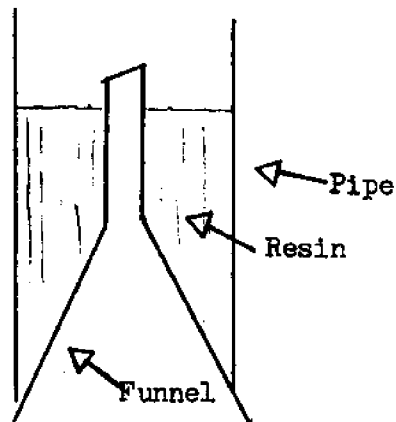
'Baseball bat' venturi



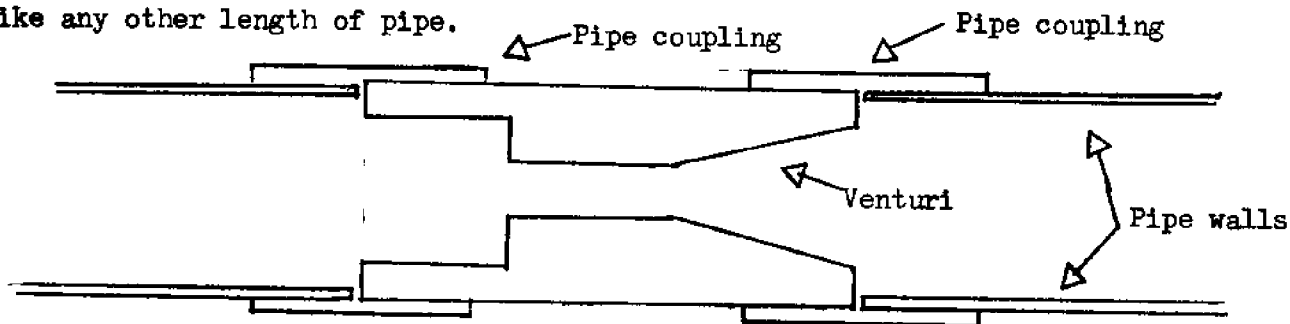
Prototype venturi



In the name of economy and convenience it would be possible to use funnels as molds for the small and mid-sized venturis. The funnel would be coated with silicone lubricant as a mold release, the appropriate length of pipe placed around it and then the resin is poured in and cured. The funnel is popped out and the air inlet is drilled. This is the same procedure that will be used for the production of the large venturi but the funnel will be replaced with a specially designed mold blank.



The completed venturis are then installed on the appropriate pipe line like any other length of pipe.



The 2" venturis will be installed on the secondary main feed line, the 1" venturis will be installed on the terminal feed lines of tanks with a high flow rate and the  $\frac{1}{2}$ " venturis will be installed on the terminal feedlines of tanks with a low flow rate. If the 2" venturis are able to deliver seawater with a  $DO_2$  level in excess of 6.5 ppm then the mid and low range venturis can be dispensed with.



### **ACKNOWLEDGEMENTS**

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Mr. Robin Otagaki, Moanalua High School  
My mother, Mrs. Alice Hong

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# Ocean Law and Policy







THE SEA'S THE LIMIT  
by Iris Shimokawa, Sacred Hearts Academy

ABSTRACT

The subject of this paper is the limit set on territorial waters and the high seas by maritime law. It explains boundary limitations, the nature and the extent of governmental regulations of territorial waters. Brief mention is made of control of the high seas, but the main purpose is to explain maritime law in territorial waters.



## Introduction

Many of us living either on an island or on a continent do not realize that our property claim could extend 3 miles more or less outward to the sea, depending on the country's governmental status.

The following report should give you a general idea of the rules, regulations and limitations which boats and other countries are instructed to observe. It also gives a brief definition of the few most important things which the limitations set.

## Territorial Waters

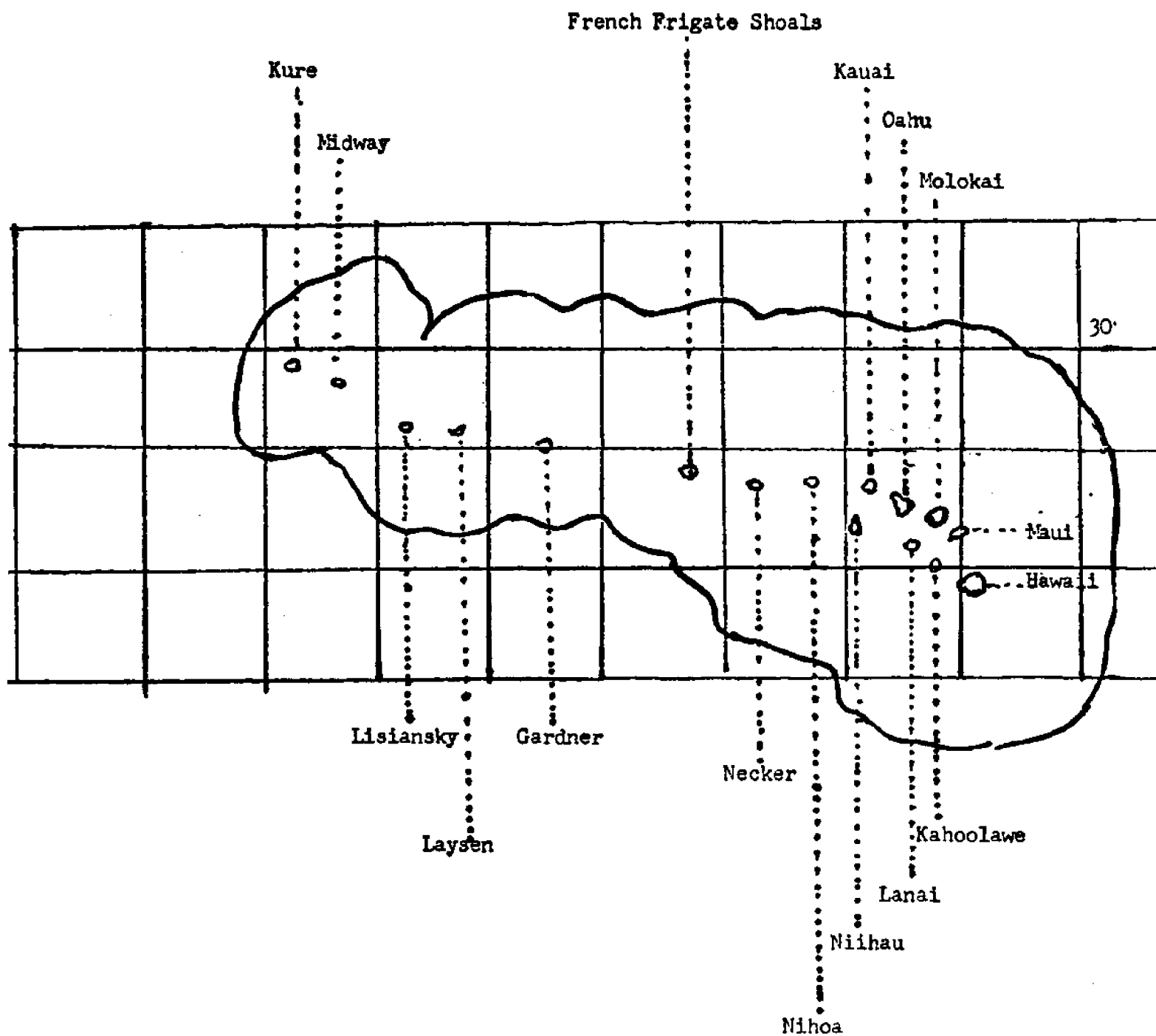
This is the area of ocean over which a nation or a state has complete control. These rights include fishing, navigation, and also shipping and the use of all of the ocean's natural resources.

A country's territorial waters include its internal water and also its territorial sea, lakes, rivers, and other waters within coastal areas such as bays and gulfs. The territorial sea of each nation lies beyond its coast. The nations have more authority over their internal waters than their territorial sea. Now you might not think there's a difference between the two, but there is. The main difference is that during the time of peace between nations, ships are allowed to enter into other nation's territorial seas.

Some nations claim fishing rights in the waters outside of their territorial seas on the high seas. This sometimes



# HAWAIIAN BOUNDARIES



This chart is taken from the Fisheries Conservation and Management Act. The boundary extends 200 miles from the shores of the islands.



causes some disagreements between the governments of different nations. Many times the United Nations has put together sessions to draw up an international treaty which would govern the use of the ocean. No matter how many times these sessions have taken place, they haven't reached an agreement which suits all of the nations involved.

Hawaii's territorial waters shall be those surrounding all of the islands put together with their reefs and territorial waters. This territory virtually stretches 1500 miles from the "Big Island" to the northern most, Kure Island.

In these territorial waters the state and federal divisions provide the necessary personnel and boats needed to patrol these waters. From the federal division there are the Coast Guard ships and from the state there are the police boats. These two both follow the laws in the ways of the Maritime Law.

#### Maritime Law

This regulates trade and navigation on the high seas or in the territorial waters. This includes all vessels from small pleasure boats to the larger luxury liners and also covers such things as insurance, contracts, property damage, and personal injuries.

All incoming vessels are required to comply with certain rules in order to enter into the port. In Hawaii any foreign or U. S. vessel coming from a foreign country must clear with or notify the U.S. Customs prior to its arrival in the 3 mile



zone. Upon arrival at the dock, the ship must also get a clearance from the U.S. Immigrations for the vessel's crew and passengers, for each must be properly "visaed" before any of the crew members or passengers may disembark. These formalities are called "pratique" clearances. The Coast Guard's responsibility is to insure that all vessels, domestic and foreign, comply with all of these regulations, unless a vessel has an emergency, i.e. a very sick crew member or passenger or a malfunction of the engines, etc.

Before entry into the 3 mile limit, the Coast Guard requires 24 hours' advance notice. If a foreign ship is scheduled to arrive on a specific day, the handling agent notifies the U.S. Customs of its arrival. U.S. ships from a domestic port do not require any clearance with the U.S. Customs.

A ship entering the 3 mile limit zone without clearance would be asked to leave the limit zone to 3.1 miles. If the warning is ignored, then the ship could be seized. But a vessel or ship may pass through the 3 mile limit zone, which is called "right of innocent passage." Trade within the 3 mile zone cannot take place. For example, a ship passing through the 3 mile limit cannot push over a container of its cargo and have another ship retrieve this cargo.

### High Seas

The ocean waters outside of the 3 nautical miles of ocean which are governed by the adjoining land are known as the high seas. These waters, according to the international law,



are for all nations to have an equal share of rights on the high seas, and all nations are supposed to observe certain rules which have been set and agreed upon. These rules are observed at all times except in times of war, where little attention is paid to the international law of the high seas.

The international law states that if any vessel arouses any kind of suspicion the ship may be searched and this is within the controlled zone of water. Ships which are suspected of breaking any revenue rule may be searched within the 12 nautical miles from the shore of the governing land according to the United States Law.

Not all of the nations accept the 3 nautical mile zone as their territorial limit, as shown by the following chart.

#### Conclusion

In this report I have discussed maritime law and how it affects territorial waters and the high seas. I have also told a little about how a nation may regulate its territorial waters, touching briefly upon the subject of boundaries surrounding Hawaii. I have learned that rules which vessels must observe and obey are not as simple as I had thought and that not all nations agree to the boundary limitations set by international maritime law.



Country	Territorial sea (miles)	Fishing Limit (miles)
New Zealand	3	12
Nicaragua	3	200
Nigeria	30	30
Norway	4	12
Pakistan	12	50
Panama	200	200
Peru	200	200
Phillippines	3	
Poland	6	12
Portugal		12
Romania	12	12
Saudi Arabia	12	
Senegal	12	110
Sierra Leone	200	
Singapore	3	3
Somali Republic	200	12
South Africa	6	12
Spain	6	12
Sri Lanka	12	
Sudan	12	
Sweden	4	12
Syria	12	12
Tanzania	50	12
Thailand	12	12
Togo	12	12
Tonga		
Trinidad and Tobago	12	12
Tunisia	12	12
Turkey	6/12	12
U.S.S.R.	12	12
United Arab Republic	12	12
United Kingdom	3	6
United States	3	200



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LAW OF THE SEA  
by Laura Young, St. Joseph High School

Introduction

The purpose of this paper is to discuss the Pacific fishing zones and the impact they have on the major fishing industries. Within the fishing zones are regulations to be observed. This paper will present the regulations of commercial fishing and the seasonal restrictions on it.

A closer look will be taken in the direction of the 200 mile limit between the United States and the Soviets. Strongly affected are the Japanese and the Koreans. They have a very large fishing industry and have a lot at stake with the U.S. and the Soviets setting guidelines.

The Marine Mammal Protection Act will also be discussed, along with new methods of lowering the mortality rate. The tuna catch could be improved or have high losses. If the tuna catch is lower than the porpoise mortality rate in weight, then we can conclude that there is a mismanagement of resources. The porpoise carcasses can be used in many different products. But should the time be wasted on storing these carcasses, weighing millions of pounds, and bringing in low prices.



A new 200 mile fishing limit has been set up by the United States and the Soviets. It was enacted in August 1975. The major result to come of this new boundary is the new bountiful harvest to be had by the United States. The Soviets have also taken a 200 mile limit. Their limit comes with a little more controversy. Their boundaries go into the Kurile Islands, which were taken away from the Japanese after World War II. The area is heavily fished by the Japanese.

Fish makes up 80% of Japan's protein. It also makes up \$7.2 billion of Japan's economy. An estimated 5,500 fishing and canning ships are idle, bringing unemployment to thousands of fishermen. In order to save their fishing industry Japan has set up their own 200 mile zone. The Kurile Islands are in both zones and that raises the question of who owns the islands.

The Koreans are also hard hit by the new zoning. But the Koreans are looking at the problem from a different perspective. They are trying to buy American processing plants and get their ships to buy the loads from American ships still at sea. Americans are upset that foreign nations will be able to exceed their quotas.

Korean and Japanese protein come from the sea. Without it they will lose a main staple of their diet and a major industry in both their countries. "Japan's very life depends upon the sea, you cannot change a 2,000 year old diet in a day."

The 200 mile limit also present new problems for the United States. There will be new regulations concerning the area. Enforcing the regulation will be the most expensive problem



facred. The Coast Guard will patrol the area but 200 miles is a lot of area to cover. The passing of judgement and conferences on the new problems will be taken care of by the Canadian Government, the United States and the Coast Guard. Limitations will be set on entry to the different areas on licensing for various fishing expeditions and limitations on catches.

There cannot be strict regulations on the zoning since the area is shared with Canada. The United States and Canada will have a working relationship that is very flexible. Disputes can break out concerning the areas. First, is the dispute between Canada, the United States and a third party, second, is the dispute between the United States and Canada and third, is a dispute within the United States.

Solutions still must be found for very important issues that take an international stand. One is the use of the waters by military vessels. If we send our militia to a foreign destination, will the Canadian government allow us to go through their 200 mile limit? Merchant vessels might also use passageways which go through the 200 mile limit, causing conflicts. Will there be freedom to do this in all areas of the 200 mile limit or will there be boundaries within boundaries? Ocean floor mining is going to be developing into a bigger industry. There will be disputes between nations for the rights of the minerals and how much mining can be done.

These subjects deal mainly with foreign relations. A reasonable settlement has to be drawn up for all parties to agree upon or the new zoning will be more of a hinderance than an expansion.



One of the first clashes between nations was the Russian ship Shechenko, which was caught 130 miles off the coast of Nantucket in Massachusetts. Also in the area was another Russian ship named the Snechkus. Both were carrying large amounts of river herring. Most of the catch was already transferred to the mother-ship, which was outside the 200 mile limit. The ship captains were given their rights in Russian and the ships were brought in. Later, the Snechkus was released, but its load of 16 tons of frozen river herring was kept as evidence of an illegal catch. The captain of the Shechenko was arrested, served a year in prison and paid a \$100,000 fine. Altogether, there were 53 previous warnings given to Soviet ships.

One of the biggest problems within the fishing industry is the tuna and dolphin battle. Beginning with the Marine Mammal Protection Act of 1972, tuna boats were given two years to begin to modify their equipment and procedures to begin to lower the mortality rate of dolphins. The dolphins are trapped with the tuna inside the nets of the fishing boats. Because they are tangled in the nets and cannot reach the surface to breathe, they drown.

The reason the dolphins travel with the tuna is unknown. The dolphins do not eat tuna. They just travel together. Because tuna is such a large industry, dolphins are caught in the large masses of tuna they travel with.

The total mortality rate of dolphins occurring in a year depends on the amount of fishing done. The average mortality rate before the Marine Mammal Protection Act was 309,000 animals.



After the passage of the Act, during the two year transition period, the number of animals killed was lowered to 137,000 animals. An estimated 340,000 dolphins were saved. From 1973 through 1977 the reduction in the mortality rate was 28%, 22%, 18% and 5%. In the two years of transition, more tuna were caught than before. Further progress was made during 1975 through 1977. The mortality rate in 1975 was 134,000 compared to 1977's 27,000 animals killed.

The incredible reduction of animals killed during the tuna harvest is due to the continuing experiments done by the National Marine Fisheries Service. During one of their experiments aboard the Bold Contender, they demonstrated all the new equipment and procedures which could be used to lower the mortality rate of dolphins.

The Bold Contender made 25 sets with a mortality rate of 1.44 animals per set. In 15 of the sets, no animals were killed. In 1975 the average amount of deaths per set was 12.80.

One person who contributed to the invention of the equipment being used for saving dolphins is Harold Medina. He is credited with inventing the porpoise safety panel and was also working on the Medina Bridle.

Medina was a tuna fisherman near New Zealand. He is a co-owner and captain of Zapata Discovery. He is from one of the families that founded the U. S. tuna industry early in this century.

One of the most common problems within the tuna industry is called a rollup, in which the nets get snarled in a steel cable



at the bottom of the net after it has been set in a large circle around the fish. So in the beginning, dolphins were not involved with the changes in the rollup of the nets. Rollup problems sometimes stopped work for hours on the ships and damage ran into the thousands of dollars.

Medina got the ideas for the improvements while watching the schools of fish being netted from a helicopter. The water is clearer near New Zealand and many tuna fishing companies are beginning to use helicopters to spot schools of fish.

Medina's idea of equipment first came in 1970, long before the mortality rate of dolphins was a concern.

Fishing for tuna there is somewhat different from tuna fishing in the more northern waters of the Pacific. Dolphins are not the problem there. Sharks are the problem. They become entangled in the nets and are more of a danger to man than dolphins are. Repairs on the nets and the boats are sometimes needed underwater, and the presence of sharks is dangerous to divers. A license to fish within the 200 mile limit costs \$50,000 and fuel is a third higher than the U. S.

The fish near New Zealand are larger than other tuna, so it takes a shorter time to fill up the hold of the ship. Also there is hardly any competition, because there is no market for tuna in New Zealand. New Zealanders do not like tuna and the fish are shipped to the United States. Fishing is also more difficult because the water is so clear the tuna can see the ships and they usually escape the nets.

Medina is experimenting with a heavy chain on the bottom of



his net so it can be set down before the tuna can escape.

A group made an assessment of whales and dolphins. It seemed that the number of bottlenose dolphins was falling because of the fishing procedures. Another assessment said that there were plenty of dolphins to go around and that the carcasses of the dolphins should be saved and used. Porpoise meat is said to be quite tasty, but there isn't a market for it in the U. S. Other parts of its body can be used for different products like pet food or fertilizer.

A statement was made showing figures that dolphins eat as much as humans in the world. Does this mean we are competing with dolphins for a food source? The problem of saving the carcasses of the dead animals would be storage space. No ship owner would give up tuna storage space that would bring a higher price than dolphins.

With our 200 mile limit enacted we are able to monitor an area once unpatrolled by the Coast Guard. The illegal fishing by the Soviets within our waters can be cut down by heavy sentencing from our judicial system. They will be very careful about entering our waters with the intent of making illegal catches if they are heavily fined. The Japanese and Koreans equally need fishing some allotment could possibly made for these two nations whos economy depend heavily on the industry. The dolphin mortality situation is slowly bettering itself. Perhaps the same type of committee that put the Marine Mammal Protection Act together could help solve the problems of illegal Soviet fishing and the failing fishing economies of the Japanese and Koreans.



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HAWAII'S COASTAL ZONE MANAGEMENT  
by Laura Knight, Castle High School

ABSTRACT

In 1972, legislation was passed by the Federal Government which encouraged the states to undertake Coastal Zone Management programs. After a period of planning by Hawaii's Department of Planning and Economic Development, the Hawaii State Legislature passed an act providing for a Coastal Zone Management Program.

The Federal requirements included a provision for the planning of the CZM program to be a joint effort of the administration and the public. The result was considerable discussion and dissent during the planning years, which eventually resulted in a strong CZM program.

Hawaii's CZM program is currently being tested, and it remains to be seen whether it will emerge as the useful and efficient program envisioned by the Federal Government.



In the past two decades, the need to conserve and protect our environment has become an ever-increasing concern. From this concern has stemmed a number of laws and acts.

In 1972, in an attempt to channel all of these laws into one effective and efficient law, a Federal Coastal Zone Management (CZM) Act was passed. This act was created in an effort to encourage each state to form a CZM program of its own. It provided for grant money to any state willing to attempt to draw up a CZM plan. Grant money would be given annually to the state during the planning years. After the state's CZM program was accepted on the Federal level, more grant money would be given for the actual environmental projects.

What is the "coastal zone"? The coastal zone area, as defined by the Federal CZM Act, is that area extending from the shore seaward to the limits of United States territory, (in Hawaii, three miles), and from the shore inland as far as is necessary to protect the shorelines.<sup>1</sup> The actual distance the latter part covers is left to the discretion of the state.

In the Federal CZM Act, it is required that each state, through legislation, accomplish the following:

1. Define the Coastal Zone boundaries
2. Define permissible uses within the Coastal Zone
3. Establish an inventory of areas of particular concern
4. Establish legal framework to control land and water uses within the Coastal Zone
5. Set priorities on the types of uses allowed within the Coastal Zone
6. Establish an organizational framework to carry out



## management of the Coastal Zone

### 7. Preserve estuarine sanctuaries of environmental significance.<sup>2</sup>

In 1973, the Hawaii State Legislature passed an act which required the Department of Planning and Economic Development (DPED) to create a Hawaii CZM program that would comply with the Federal standards and objectives.

The DPED received its initial grant money during the fiscal year of 1974-1975. During the first year of a three-year planning program, the DPED made a groundwork inventory of current coastal zone situations, and developed a number of tentative plans for a CZM program. Now they were ready to start creating the actual program.

The main purpose of the Federal CZM Act was to establish a program which would be the most effective way of protecting our coastal zones, and at the same time, be legally efficient, so that our environment would be protected to the fullest. To achieve this high goal, the government felt that the more viewpoints that went into the planning of the actual act, the more efficient it would be in the long run.

To ensure that the states followed through, certain clauses were put into the Federal CZM Act of 1972, e.g. "With respect to implementation of such a management program, it is the national policy to encourage cooperation among the various state and regional agencies . . . "<sup>3</sup> This idea was also incorporated into the CZM Planning Act of 1973: " . . . assisting the states, in cooperation (emphasis added) with the federal and local governments and other vitally affected interests, to plan and develop management programs . . . "<sup>4</sup>

The Federal DPED Act stipulated that, before receiving program approval at the federal level, the CZM program had to have been planned with the help



of " . . . Federal agencies, state agencies, local governments, regional organizations, port authorities, and other interested parties, public and private . . . " <sup>5</sup> Also, the Federal Act stated that public hearings had to be held with respect to CZM program developments. Each meeting had to be announced at least one month ahead of time, and all documents and other pertinent information had to be made available to the public at announcement time, so that the public would have time to review background information.

The Federal Government demanded full cooperation between all organizations and agencies involved in the creation of the Hawaii CZM plan. The Government also required that the public be given an equal share of input. In this way, it was hoped, the product would be a well-rounded and useful CZM program with which to protect our coastal areas. This paper will discuss whether these two requirements of the Federal Act were carried out by the state CZM program designers, and whether the requirements helped to build a stronger program.

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In 1975, the Hawaii State Legislature passed Act 176. This act was called the Shoreline Protection Act. It established a temporary Special Management Area (SMA) which extended at least 100 yards inland from the shoreline, to form a sort of doughnut shape around the islands. Each county was responsible for administering permits and assuring the protection of the environment within this 100 yard area.

During the second year, the options for possible CZM programs were



going to be narrowed down into the one preferred. To advise the DPED, a number of different committees were formed.

The State/County CZM Policy Coordinating Committee (PCC) held its first meeting in March, 1975. The committee was composed of different State and County officials. In this way, all the conflicting views could be ironed out, and the finished product that the DPED would receive would be the compromised advice of people who were going to be involved in the legal aspects of the CZM act. When it came time for projects to be processed through legal channels, they would go through in such a way, it was hoped, as the majority of officials could agree upon.

The Statewide Citizens Forum (SCF) held its first meeting in August, 1975. The purpose of this committee was to gather the views of the different organizations in the state, thus preserving all the varieties of beliefs. The committee was composed of representatives from all the different corporations and groups, ranging from the big business interests to the environmentalists.

Other committees formed with these same objectives in mind were the County Citizens' Advisory Committees (CAC). There were seven such committees altogether: Honolulu, Maui, Lanai, Molokai, Kauai, East Hawaii, and West Hawaii. Each of these committees was made up of people from all over the islands. They represented the people. A person from each CAC was sent to the SCF for further representation.

So, the DPED was being advised by three different types of Committees, ranging from official to grassroots. It was hoped that the CZM program would reflect this variety of views, and would be much more useful as a result.

Was the public really being kept up to date, and being given a chance



to have its voice heard? Yes, the SCF meetings were open to the public. By looking through the SCF minutes one can see that the public did not remain silent, and that furthermore, their questions were answered.

The County Advisory Committees were all aiming toward a high level of public awareness. For the first months of their existence, they made themselves acquainted with the CZM Act, and with the goals set for the program. Then most of them set out to teach the public what they had learned. They held public hearings to discuss the CZM program and to get input from the public.

A newsletter called Coastal Zone News was started in May of 1976, and continues to be published monthly. In it are articles that keep readers up-to-date on CZM issues and progress. It also aims to increase public awareness of the environment. For instance, during the months of January, 1978 to May, 1979, in a sixteen-part series, Coastal Zone News explained what an ecosystem was, and then went on to give examples of all the different kinds of ecosystems. In this way, the public was being made aware of the delicate and intricate patterns that make up our environment. There was also a letter-to-the-editor column in which the many questions the public had to ask could be answered. All pertinent meetings being held were usually announced in the CZ News, and many names and addresses were given for "more information". This newsletter was free and available at the CZM office at the University of Hawaii, to anyone who simply provided his name and address.

In 1977, the Hawaii State CZM Act (Act 188) was passed. This act was to be the cornerstone on which all other Hawaii coastal zone legislation would rest. The particular areas it was primarily concerned with were:



1. Provision and protection of recreational opportunities
2. Protection and restoration of historic resources
3. Improvement of scenic and open-space areas
4. Protection of coastal ecosystems
5. Provision for coastal-dependent economic use
6. Reduction of coastal hazards
7. Improvement of the review process involving developmental activities, including permit coordination and opportunities for public participation.<sup>6</sup>

Not only did the state law set forth these ideas, but it also revised other previous acts, updating them so that they would be more useful. The counties were given two years to revise their Special Management Areas according to CZM requirements. At the end of those two years, (previously set for June 8, 1979, later amended to December 31, 1979), the SMA were to be brought before the DPED for review, and if it was decided that the revisions followed CZM policy, they would become the final SMA.

In Act 188, the DPED and other state agencies were given jurisdiction over the three-mile zone from the seashore outward to the end of U.S. territory, and all the area inland from the County SMA (excluding Federally controlled land). So, in effect, the entire state was to be under CZM protection. The protection zone issue caused many arguments.

One main argument was that if the objective of CZM was to make legal channels less complicated, then by making two separate managing bodies, state and county, the opposite was achieved. Other people felt that in order to protect the shorelines, the entire state had to be included in the Special Management Areas.

Out of these conflicting views emerged two bills. The counties



introduced HB1113 and the state introduced HB1642. Essentially, the counties wanted the SMA to cover only the original 100 yards, with revisions, and possibly including a few crucial areas inland, provided they were given more revision time. The state believed that the double management system was fine, with the exception that, since there was going to be such a large extent of protection inland, the counties would have the option of making the revisions. Both bills contained the opinion that the general coastal zone management guidelines should not be referred to for interpretation. The state believed that the DPED (a state agency) rules and regulations should be used. The counties felt that the Hawaii State Plan and the County General Plans should be used. The only item both sides agreed upon was that public hearings should be either optional or not always necessary. It appears that the two bodies were making a play for power.

The State Legislature compromised. They passed Act 200 in April, 1979. The 100 yard SMA would remain, with the deadline for revisions on December 31, 1979. The SMA could be reduced in places, but only after review by the DPED. The area inland and the three-mile water zone were to be monitored by the state. When interpretation was needed, the legislature would do so. Public hearings were not necessarily required. Under Act 200, a person or organization has the right to bring suit against anyone not complying with the CZM objectives and policies.

It may seem wrong that there was this clash for power between the state and counties, and that it is a bad reflection upon CZM that this clash would ever occur. On the contrary, had there not been the stipulation in the Federal CZM Act forcing the DPED to work with such a wide variety of committees and other local powers, then the clash would never have



occurred. The DPED would not have been forced to compromise; it would have had sole control. The citizens of Hawaii end up with a stronger and better CZM program.

On October 1, 1979, the first grant money for the actual environmental projects was received. Now, after the years of planning, the program could be applied. It was still being amended, but the basic framework had been built.

In 1974 a Japanese corporation bought 1,030 acres of land from the Ulupalakua Ranch. The purchasers wanted to re-zone the land from agricultural to urban. To do this, the State Land Use Commission had to grant permission. Many people protested; nevertheless, the Commission granted permission to re-zone 500 acres. The Japanese buyers were planning to build a large complex near Makena Beach, with houses, hotel units, and even a large shopping center. In 1975, the corporation drew up an Environmental Impact Statement, as required by law. Though the comments written by the public gave evidence of the danger of the project to the aesthetic and environmental sides of Makena Beach, the EIS draft was accepted. The corporation had the go-ahead.

The corporation began having financial troubles, causing a delay in construction. By the time they were ready to build, they were required to obtain a SMA permit. The public meeting was scheduled for May 8, 1979. At this meeting, a petition was presented with 200 signatures of people against the project. The meeting was very crowded, and a total of twenty-four people spoke. Four were for the proposal and twenty were against. Despite heavy public disapproval, the SMA permit was granted. Taking advantage of the rights given them through the CZM Act 188 and amending Act 200, the



People to Save Makena and the Sierra Club pressed charges against the Maui Planning Commission, on the grounds of disregarding CZM requirements.

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Were the two Federal requirements, cooperation of government agencies, and public participation, carried out? Did they help to make a strong Hawaii CZM program?

During the planning of the Hawaii CZM program, the governmental and public committees were forced to work together. When the pressure built up, the legislature stepped in to create a compromise, an action which strengthened the CZM program. Also during planning, the public was constantly being given information, and meetings were usually open. In these ways, the CZM program received the views of the people who were going to be the most affected.

However, when it was put to the test, a problem arose; the public which was so important during planning was now being ignored. The CZM standards, in fact, were essentially being discarded. Was the program that took so much hard work and diligent planning during development going to fail when put to the test?

This question cannot be answered until the Makena case goes through the courts. Yet, there are two reasons to be optimistic. First of all, the right of the public (the people) to press charges against violators of the CZM Act is built into the law. Secondly, because of the careful planning that went into the program, the legal guidelines are clear.

Hawaii's Coastal Zone Management program, through the Makena case, is now on trial. If the judges rule in favor of the plaintiffs, then we will know that Hawaii's CZM program is as strong and useful as it was meant to be.



## NOTES

- <sup>1</sup> State of Hawaii Coastal Zone Management Program and Final Impact Statement. U.S. Department of Commerce; NOAA; Office of Coastal Zone Management (1978), p. 2.
- <sup>2</sup> Hawaii Coastal Zone Management Program, (Regional Library Information file), Folder "D", Meeting Minutes, 1st meeting.
- <sup>3</sup> Public Law 92-583, 86 Statute 1280, p. 2.
- <sup>4</sup> Act 164, SLH73, p. 1.
- <sup>5</sup> PL 92-583, p. 4.
- <sup>6</sup> State of Hawaii Coastal Zone Management Program, p. 9.

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- Kaneohe Regional Library; Hawaii Coastal Zone Management Program Informational File; Folders B, C, D, E, and F.
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- The Sierra Club, Hawaii Chapter; Malama I Ka Honua; December, 1979.



