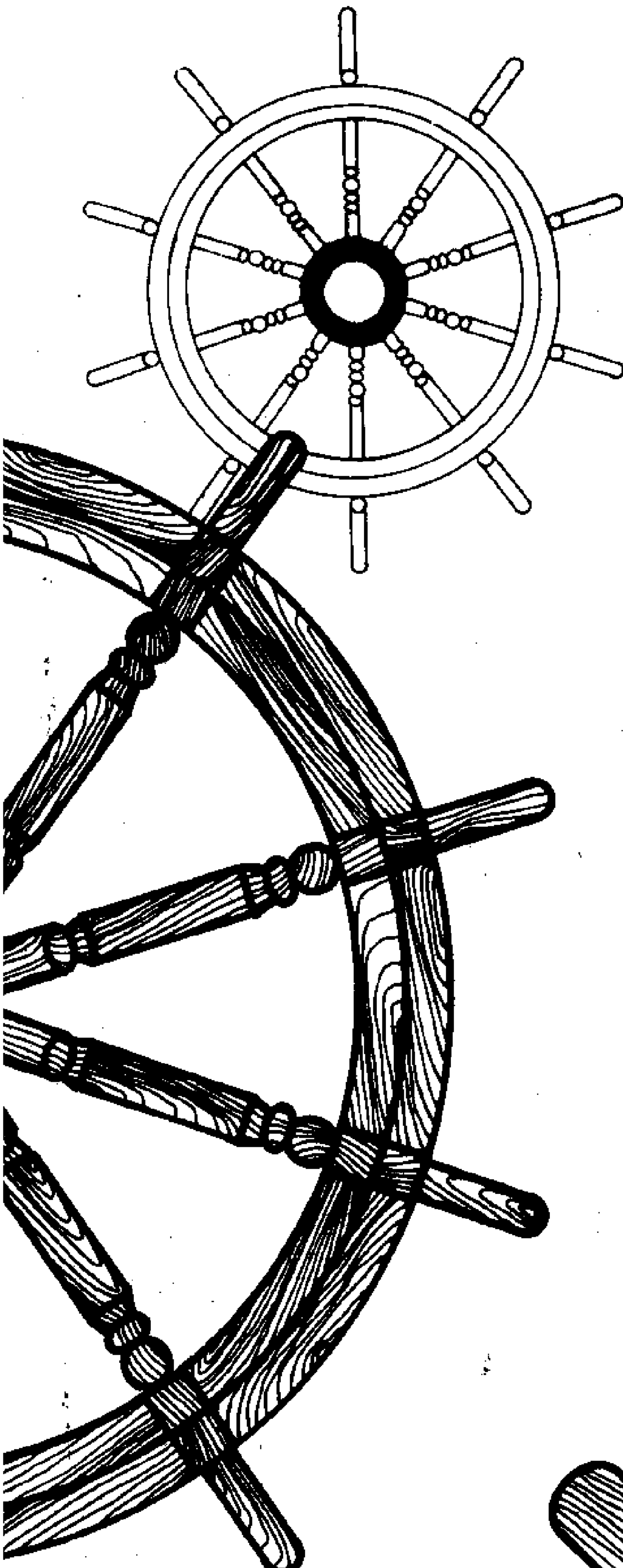
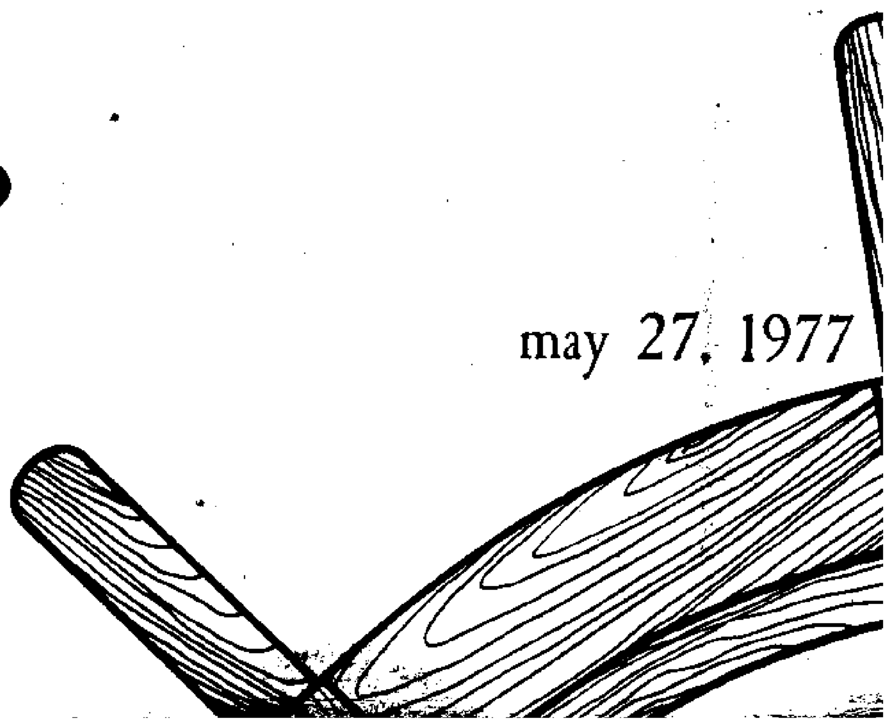


proceedings of the
second annual

student symposium on marine affairs

may 27, 1977



UNIHI - SEAGRANT - MR - 77 - 02

Sea Grant College Program
University of Hawaii

PROCEEDINGS OF THE SECOND ANNUAL STUDENT SYMPOSIUM ON MARINE AFFAIRS

Sea Grant Miscellaneous Report
UNIHI-SEAGRANT-MR-77-02

May 1977

SEA GRANT
UNIVERSITY OF HAWAII

This proceedings of the Second Annual Student Symposium on Marine Affairs, which will be held at the University of Hawaii Manoa campus, May 27, 1977, is published with funds provided by the Sea Grant College Program, University of Hawaii, under Grant No. 04-6-158-44114.

PREFACE

This volume of the Proceedings of the Second Annual Student Symposium on Marine Affairs, which will be held on May 27, 1977, at the University of Hawaii Manoa campus, contains twenty-eight papers in six categories: ocean engineering, marine resources--fisheries management, aquaculture, marine resources--manganese mining, coastal zone management, and marine biology.

We have not attempted to edit the papers but wish instead to give credit where credit is due, to the thirty-three students and their teachers:

AIEA HIGH SCHOOL

Kathy D. Neill (Miss Betty Hart)

CAMPBELL HIGH SCHOOL

Susan M. Anthony (Mr. Ronald Pisciotto)

HILO HIGH SCHOOL

Rene M. Tanaka (Mr. David Raabe)
Linda M. Tao (Mr. David Raabe)

KAILUA HIGH SCHOOL

Jan K. Miyashiro (Mr. Raymond Rounds)
Lee E. Tasaki (Mr. John McMahon)

KALAHEO HIGH SCHOOL

Lisa A. DeLong (Mrs. Virginia Bickmore)
Heidi K. Ranta (Mr. John McMahon)

KAPAA HIGH SCHOOL

Tina L. Daehler (Mr. Delano Kawahara)
Laura L. King (Mr. Delano Kawahara)

LAHAINALUNA HIGH SCHOOL

Marc M. Nishimoto (Mr. Donald Chaney)

MCKINLEY HIGH SCHOOL

Randall T. Chun (Mr. John Hawkins)
John K. Ogoshi (Mr. John Hawkins)
Catherine F.T. Uyehara (Mr. John Hawkins)
Joel P. Yuen (Mr. John Hawkins)

PAHOA HIGH SCHOOL

Arlene D. Bazell (Mrs. Sandra White)
Alfred A. Calantoc (Mrs. Sandra White)
Stephanie Cunningham (Mrs. Sandra White)
Venus Hauanio (Mrs. Sandra White)
Scott D. Snider (Mrs. Sandra White)
Betty Tampon (Mrs. Sandra White)
Robert S. Williams (Mrs. Sandra White)

PUNAHOU ACADEMY

John E. Sisson (Dr. R. Pfeffer)

UNIVERSITY LABORATORY HIGH SCHOOL

Hinda L. Diamond (Miss Faith Paul)
Edward C. Hylin (Miss Faith Paul)
Sarah E. Kennedy (Miss Faith Paul)
Galen H. Kuwamoto (Miss Faith Paul)
Robert P. Mumford (Miss Faith Paul)
Carol S. Okimoto (Miss Faith Paul)
Andrew B. Simson (Miss Faith Paul)
Matthew S. Varney (Miss Faith Paul)
Jo L. Whitman (Miss Faith Paul)
Holly C. Yamane (Miss Faith Paul)

We gratefully acknowledge the support and cooperation of the Department of Education, State of Hawaii.

Rose Pfund, Coordinator
Student Symposium on Marine Affairs

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

OCEAN ENGINEERING

SEA EXPLORER I

by Scott D. Snider, Pahoa High School

ABSTRACT

The underwater living habitats have aided man greatly in the study and exploration of the ocean. Someday inventors will dream up some design so we can harness energy, gather food, and find shelter in the vast blue sea.

This paper is a discussion of a habitat that I have designed to accomplish just such goals.

Sea Explorer I

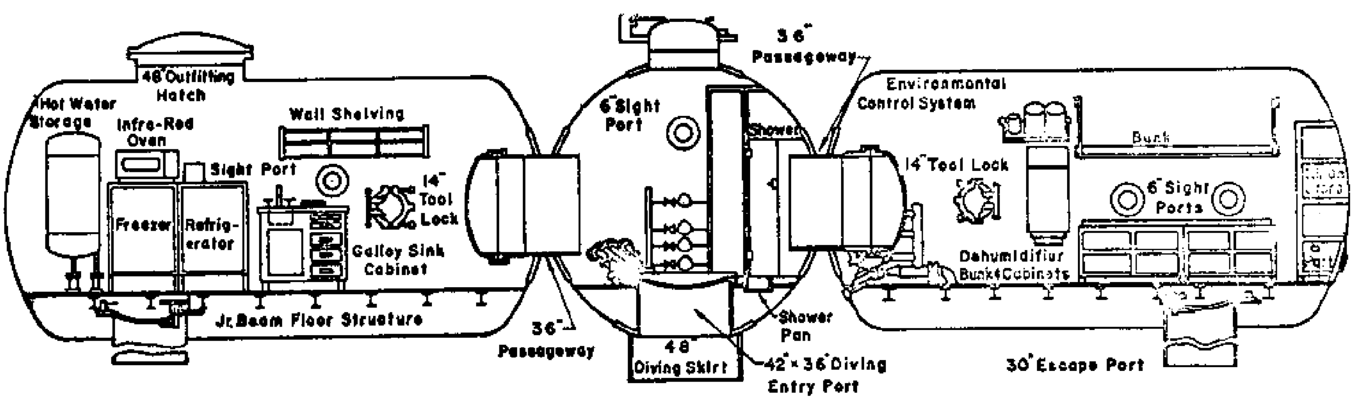
Introduction

Submersibles of the Past;

The underwater living habitats so far have made underwater study and research improve by far. With these past habitats we have been able to study orginisms in their true environment. We have also have been able to see the eefects on men exposed to long saturation dives. The only thing these habitats are hindered by is the fact that they are stationary. They have no forward or reverse movement at all. They can only stay as long as the O2 supply lasts. They can only go down once and come up before reloading heavy ballast tanks. With my theory I have solved a couple of these problems.

The insides of my habitat will be larger but unfortunately will have the same "squeaky voice" problem because of the breathing of helium. So far men have built showers, special toilets, and exellent environment control systems. These aid in the comforts of underwater living.

Usually a habitat consist of living quarters and a small labrotory. They also have a diver entry port and an excape submerible in case of an accident. This is a drawing of the arranged cabin of habitat Agier (built on Oahu)



LAB SPHERE LIVING

Sea Explorer I

Introduction

Submeribles of the Past (cont.):

n the outside of the living space are kept tanks filled with a breathable gas mixture*. Also there are caneras, radio equipment and batteries to run the electrical equipment.

Now I will expain in depth the underwater living habitat Sea Explorer I I designed. I reasarched on this project for four months gathering little knowledge every week. These next pages will show what I've learned and made up to produce Sea Expborer I.

Dicussion

My theory of an underwater habitat is a simple one; an underwater learning laborotory. I think the only way toy can learn is to see it yourself so I designed a habitat that is moveable.

My theory of moving a habitat goes like this: after it first lands on the ocean bottom and needs to be moved it should rise and be propelled to the next spot. Then it should again again to the bottom. This may seem the same as the old way and it is excet fob the fact that it doesn't need to change heavy ballast every dive and it doesn't touch surface.

What happens is a heavy duty butyl Rubber Pontoon is filled with gas by a compressor**. This makes the habitat rise and then it can be propelled by an underwater engine. When the scientist would like to stop they should have a diver scout the area or look out the ports and decide where to land.

* See page 6

** See page 7

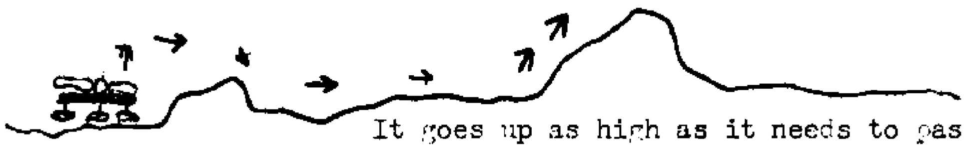
Sea Explorer I

[illegible]

[illegible]:

The compressor pumps the gas out of the pontoon and then the habitat drops to the sand. The sea floor may not be level and I'm proposing that underwater hydrolics be used to level the habitat*. I've not had enough time to see any hydraulics underwater on T.V. or in books. So if it is possible so will my level device be possible. My habitat will have two lab areas so more study of underwater can be possible. There will be an escape vehicle in case of accident. I suggest it be a four man mini sub. (So no one has to draw staws.)

One thing I haven't consdered, or looked into, is the decompression factors. Being a SCUBA diver myself I know how dangerous it is to come up not following the dive tanles. What happens is when you are underwater and breathing compressed gas you absorb nitrogen in your body. This is called the bends. When diving in a habitat after a certain time (depending on depth) a diver becomes saturated with nitrogen. This has no effect on the diver until he comes up. According to Boyles law, gas will expand when pressure is released. So when you come up the nitrogen, usually in joints, expands and causes much pain in the joints. If the nitrogen is in your blood stream and expands and a bubble goes to the brain or heart its all over. To avoid this you must come up slowly and in stages. Example 200 ft. for 20 mins., 150 ft. for 18 mins. and so on until you reach the surface. What I haven't looked into is the fact that when my habitat moves I don't know if it goes through decompression of not. My habitat moves like this :



It goes up as high as it needs to pass terrain.

I figure that no decompression is needed unless a mountain or high ridge has to be passed. If decom. is needed it will probably have to be figured out on a computer, since the rise and fall will vary greatly.

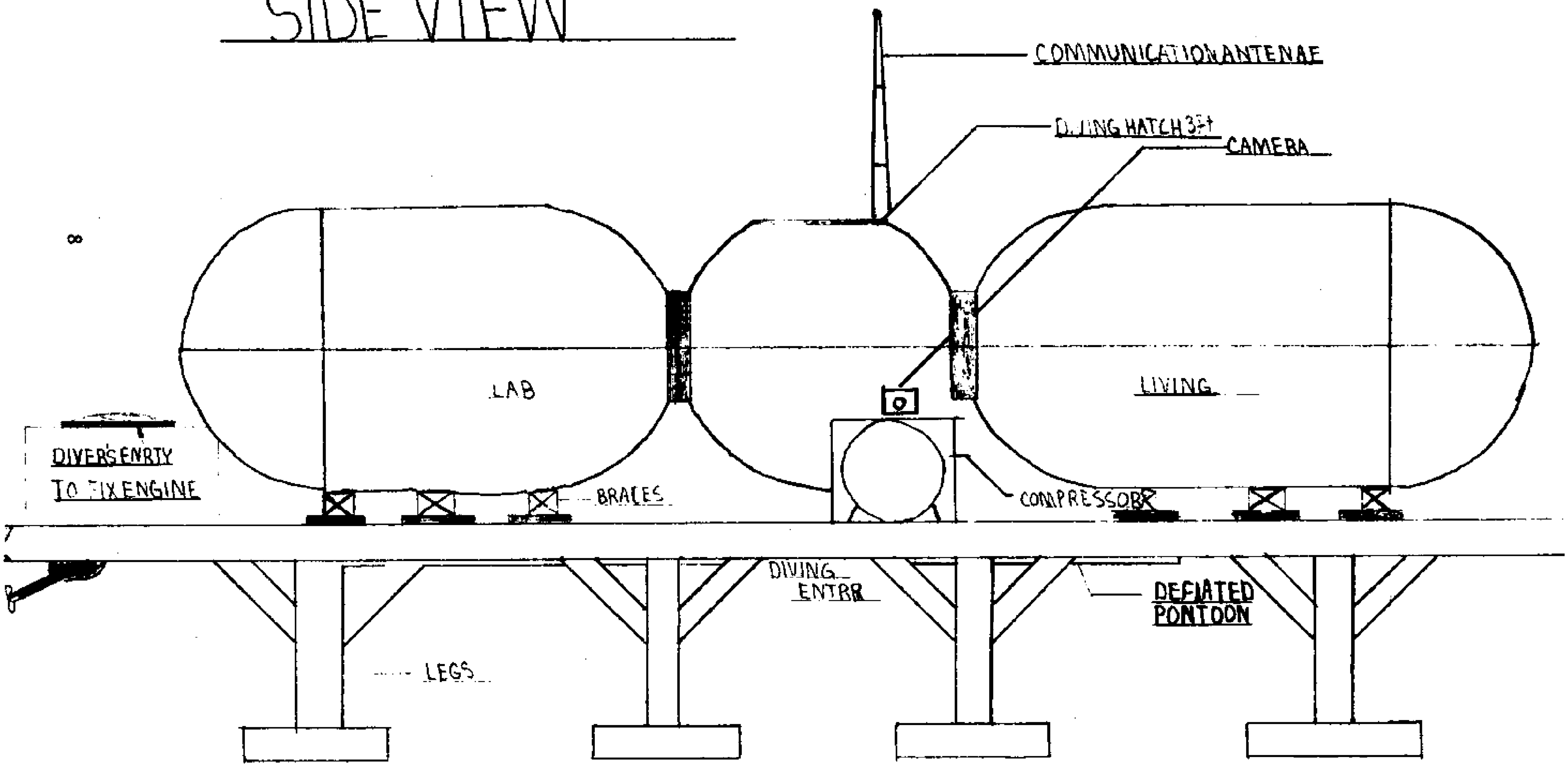
I've already said that there will be two labs and one living quarters area*. One of the labs be designed by me. It will have a decompression meter or a small computer to work the decom. problems. It will have a book shelf and lab equipment fit for the task of the Sea Explorer I. It will have space for recording machines and other equipment for different underwater experiments. It will have a storage for food and clothes and also a tool box. Maybe a book shelf and tape deck could also be added for more at home feeling*.

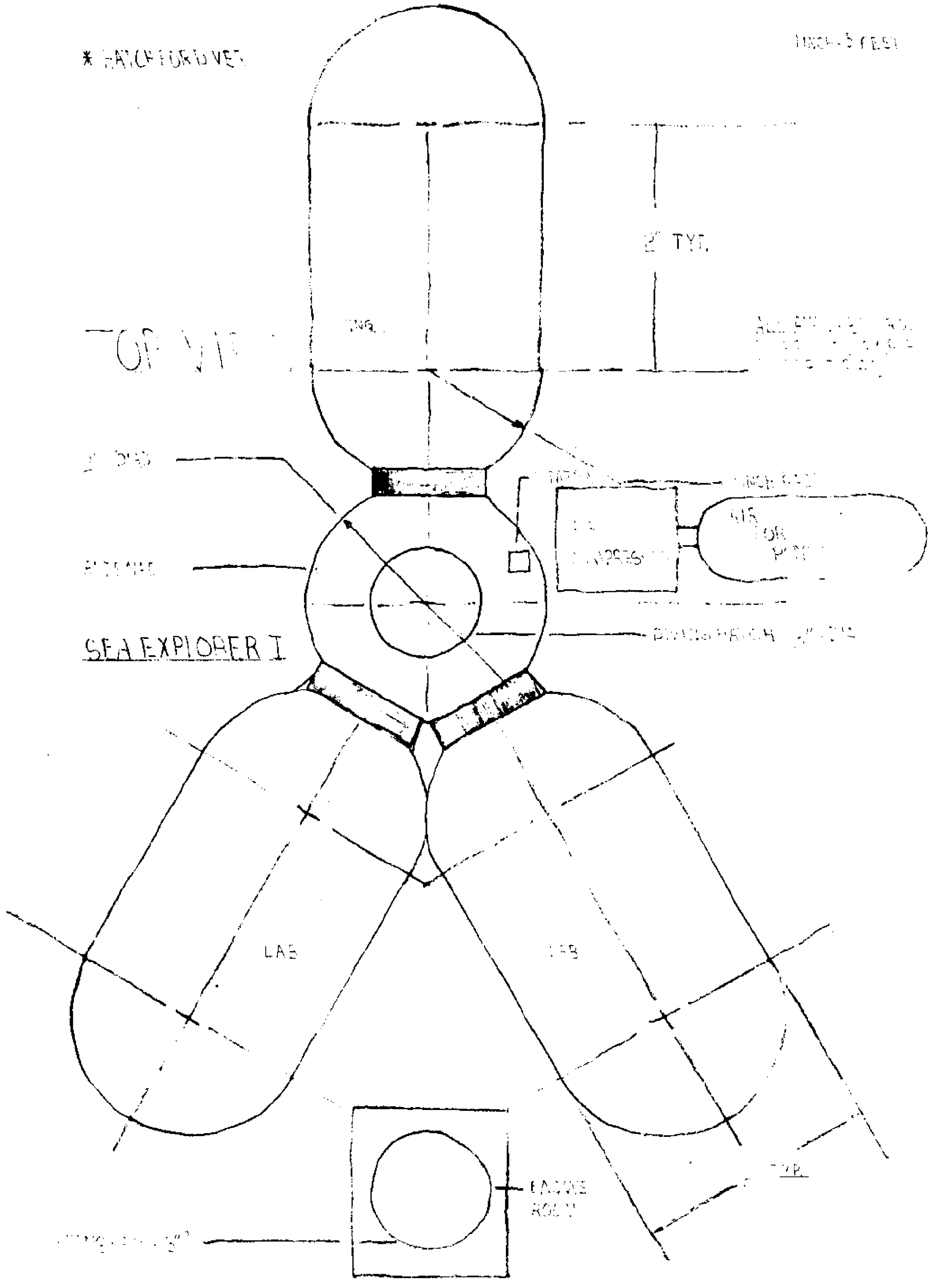
I have explained all the details of my underwater living habitat Sea Explorer I. It is to my knowledge that all of the theories work and maybe someday a project similar to mine or with some ideas from mine be built and tested. I hope these ideas of mine help man reach the ultimost goal which is living in a working peaceful environment under the sea.

*See page 2

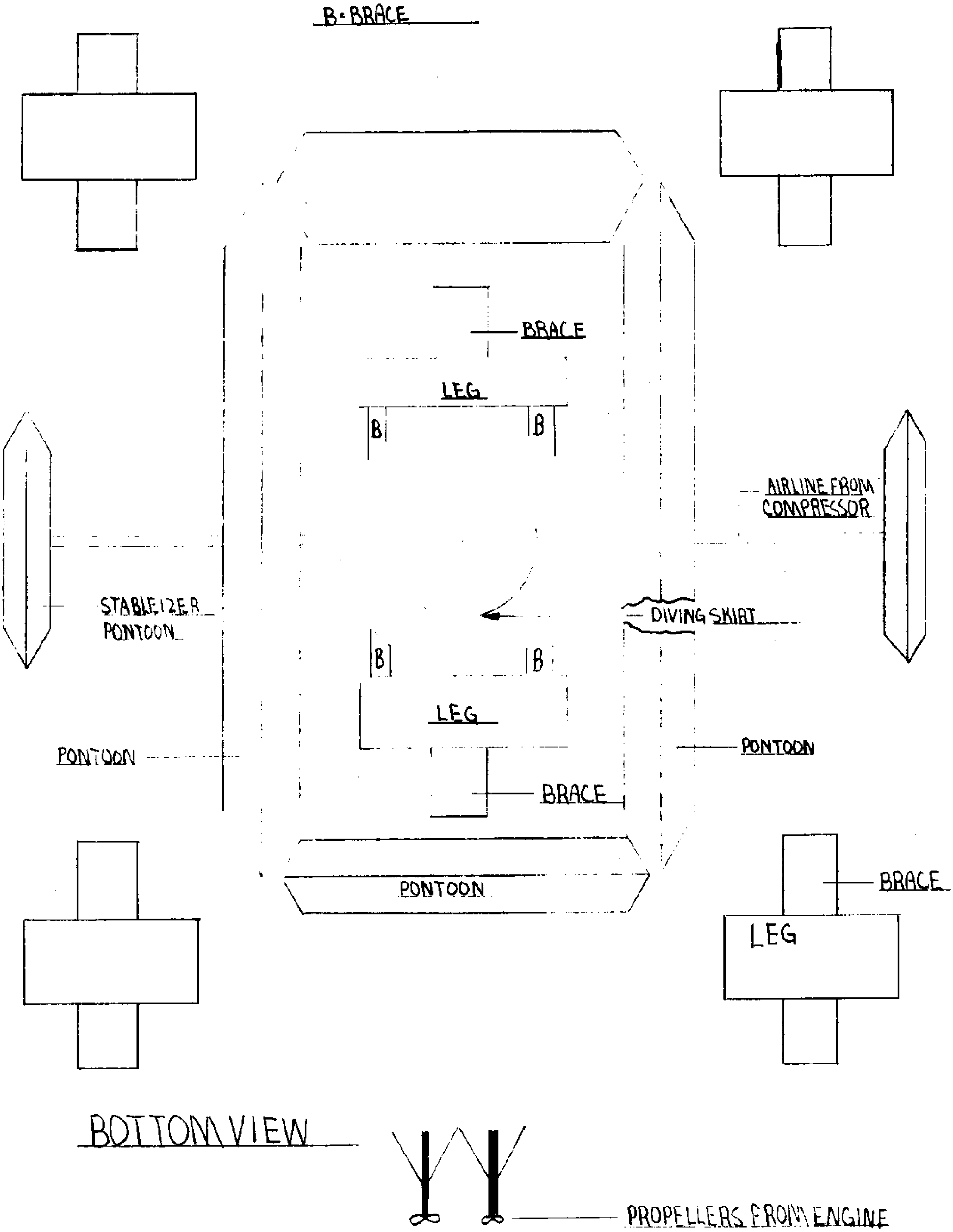
SEA EXPLORER I

SIDE VIEW





SEA EXPLORER I
2' TYP.
LAB
LAB


B-BRACE
BRACE
LEG
B
B
AIRLINE FROM COMPRESSOR
STABLEIZER PONTOON
DIVING SKIRT
B
B
LEG
PONTOON
PONTOON
BRACE
PONTOON
BRACE
LEG
BOTTOM VIEW
PROPELLERS FROM ENGINE

BIBLIOGRAPHY

Aerospace Medicine, Volume 42, Number 12. December 1971.

Henry Horn, President Makai Ocean Engineering, Inc. letters 1976-77.

McInnis, J. B. The Psychology and Medicine of Diving and Compressed Air Work. 1969.

Pegg, John. Five Day Ocean Stauration Dive Using a Mobile Habitat.

An Analysis of the Possibility of using Ocean Thermal Energy Conversion to power Floating Cities.

by Edward C. Hylin and Jo L. Whitman
University Laboratory School 3/10/77

A Floating City basically consists of a hemispherical structure, supported above the water by pillars resting on sub-surface pontoons. Ocean Thermal Energy Conversion (OTEC) plants are anchored or floating ocean structures, which use heat exchange engines to extract energy from the temperature differences between different layers of ocean water. Because Floating Cities and OTEC plants appear to be analogous structures, we decided to analyse the possibilty of using an OTEC plant to provide a Floating City with electric power.

Both advantages and disadvantages result from using OTEC plants to power Floating Cities. The greatest disadvantage is that OTEC plants could probably only be used in the tropics and in warm water currents. The greatest advantage is that it may be cheaper to use an OTEC plant rather than a conventional plant to power a Floating City. There are also technical and legal obstacles thatmust be overcome before either structure could be built, though these apply to each structure individually rather than as a whole. In the end, only a weighing of the aforementioned advantages and disadvantages will determine whether or not an OTEC plant is a viable powersource for a Floating City.

An Analysis of the Possibility of using Ocean Thermal Energy Conversion to power Floating Cities.

by Edward C. Hylin and Jo L. Whitman
University Laboratory School 3/10/77

The concepts of Floating Cities and Ocean Thermal Energy Conversion (OTEC) have been discussed often in recent years. Since some designs for OTEC plants call for a floating ocean structure, we decided to investigate the possibility of integrating the two concepts; using an OTEC plant to power a Floating City.

The idea of Floating Cities has been advocated by various groups of people, including R. Buckminster Fuller, a group of scientists at M.I.T., and others. Dr. John P. Craven of the University of Hawaii has contributed to the concept the ideas of supporting the city on submerged pontoons, and organizing it with regard to population densities. A Floating City as visualized by Dr. Craven consists of three parts. Part A is a hemispherical portion which is above the surface of the ocean, Part B is the transportation level on the surface, and Part C is the portion for bouyancy, stability, and industry, consisting of pontoons submerged several hundred feet underwater. Parts A and C are connected only by elevator shafts, leaving most of the surface of the ocean free for vessels to pass through.

Part A would be organized somewhat like a beehive, with the greatest concentration of population being in the center, and density decreasing outward. Therefore residential areas would be on the outer edge of the hemisphere, with the top being a park or a open area. As one traveled toward the center, one would arrive at the next group of activities which need a somewhat greater density of population, such as shopping centers, stores, restaurants, hospitals , businesses and other service centers. In the center of the hemispherical complex would be high density activties like theaters, stadia, churches, schools, gyms, and so on. Throughout this complex vertical transportation would be by elevator, while horizontal motion would be by walking. Carts and freight elevators would be used to move goods. Wastes could be removed vertically to a level just above the surface of the ocean, or could be separated for processing.

Part B is the surface of the ocean, which is used for transportation. Hydrofoils could provide rapid, comfortable transportation to many points on land. The traditional ferry could be used for inexpensive transportation of a large number of people, and submersible craft would provide a relaxing mode of transportation, which could be used even in rough weather. Barges could provide transportation for commodities such as food, clothing, and mail. Some provision could be made for pleasure craft. Perhaps some shelter for vessels should be made under the city to protect such vessels from being smashed against the structure by large waves.

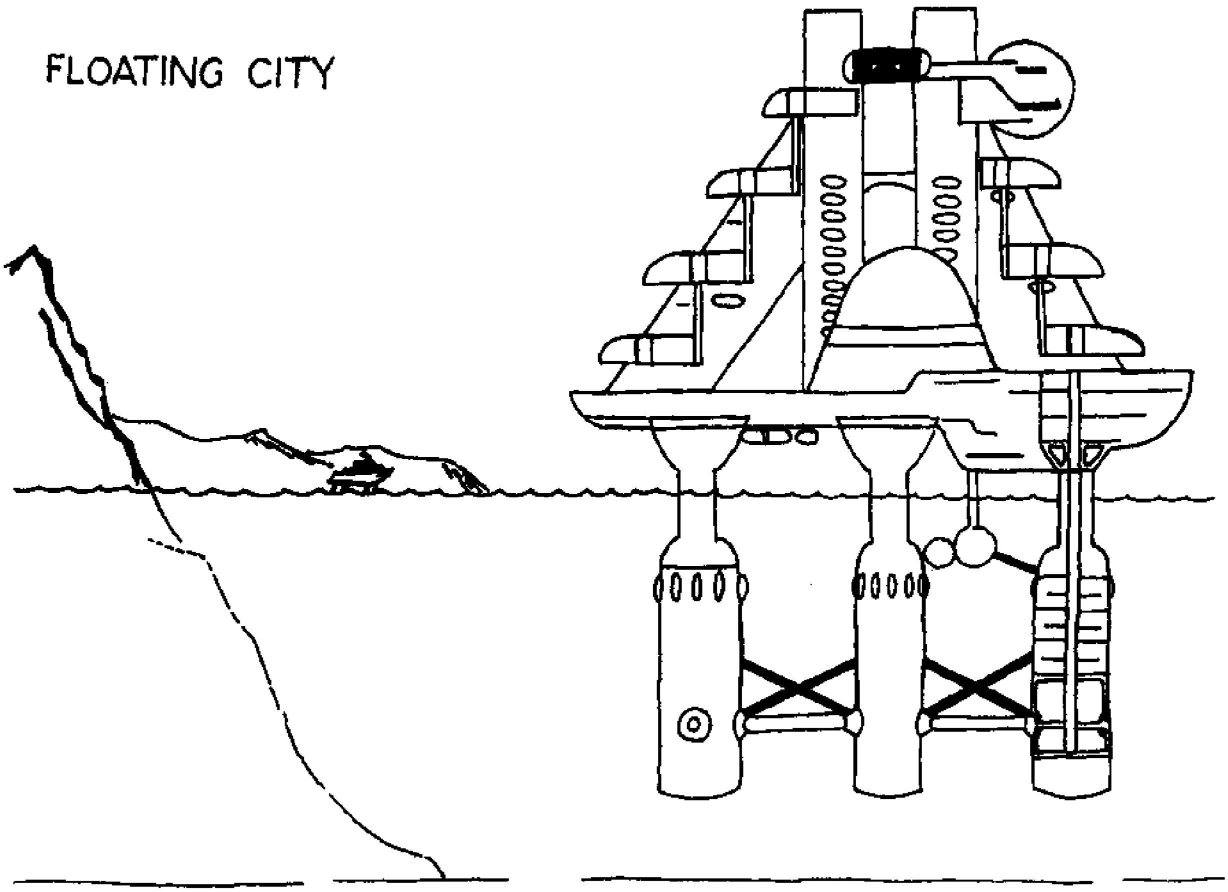
The pontoons of Part C are huge submerged structures which are there to provide stability and bouyancy to the city. Thes pontoons could be either vertical or horizontal, and would be a good place to situate light industry, where it won't bother the residents or pollute the city. Industrial wastes could easily be deposited in the sea, or transported to the surface to be disposed of with other wastes. The surrounding ocean water could be used for cooling machinery,etc. The pontoons could also be used for storage of supplies,such as fresh water, or this area could be used to house the powersource for the Floating City, for example, an OTEC plant.

OTEC plants utilize the temperature differences between various depths of ocean water to create electricity. The idea of using thermal gradients in the ocean to produce energy was conceived by two French scientists: first Jacques d'Arsonval and then by Georges Claude. More than forty years ago Claude built a small 22 kilowatt OTEC plant on Matanzas bay in Cuba, but only recently has the concept gained much attention.

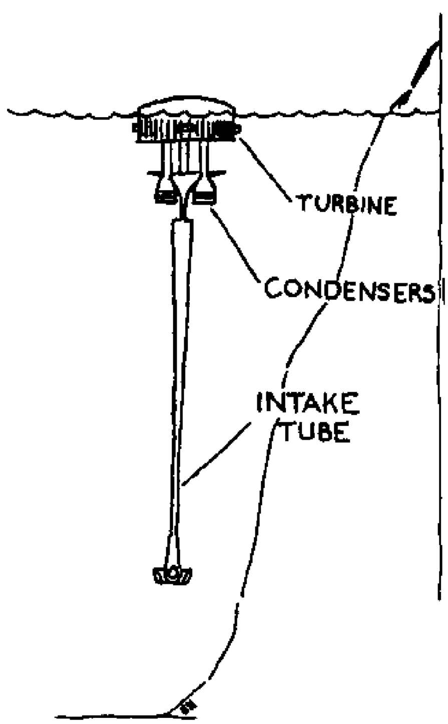
There are two general types of OTEC plants: "open cycle" and "closed cycle". The open cycle plant utilizes the fact that water boils at a lower temperature when the atmospheric pressure is decreased. In the open cycle OTEC plant, this boiling is accomplished in what is known as a "controlled flash evaporation process". Surface ocean water at about 25°C enters an evaporation chamber where the air pressure is maintained at about 25 torr (0.5 psi). In this chamber the water flashes into steam, which is then used to drive an expansion turbine. From the turbine, the steam flows into a condenser, where it is cooled into liquid again by cold deep ocean water pumped up for that purpose. The water from the condenser is then discharged into the ocean.

A closed cycle OTEC plant uses what is known as a Rankine cycle engine. This engine uses a working fluid such as propane or ammonia, which boils at a high vapor pressure at about 24°C. This fluid is first compressed and then goes into an evaporator, where it boils into gas at

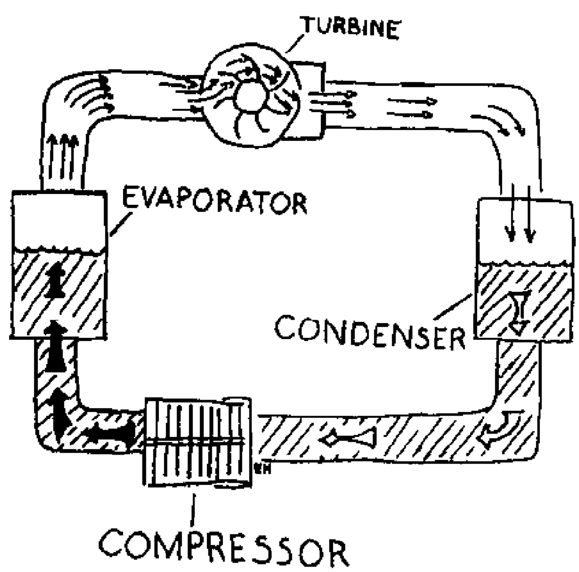
FLOATING CITY



OTEC PLANT



SCHEMATIC of RANKINE CYCLE ENGINE



high pressure. The evaporator is powered by a heat exchanger, which transfers the heat from warm ocean water to the working fluid. From the evaporator, the pressurized gas flows into a turbine. The cycle is then repeated.

An OTEC plant costs more to build than a fossil fuel powered plant of the same capicity, but the fuel (warm and cool water) for an OTEC plant is free. For a structure such as a Floating City this fuel has the advantage of being the most readily available energy source, since other fuels must be transported to the Floating City. In this paper we will analyze the advantages,disadvantages, and obstacles to powering a Floating City with an OTEC plant.

In addressing the topic of this paper, we first obtained information on both Floating Cities and OTEC plants. We arranged an interview with Dr. Craven, who is Dean of Marine Programs at the University of Hawaii, for the purpose of obtaining information about Floating Cities. For this purpose we also made a phone call to Mr. Guy Rothwell at the Oceanic Institute. From our Social Studies teacher, Ms. Faith G. Paul, we obtained several reports and pamphlets from which we extracted the information we needed on OTEC plants. By comparing and analyzing the information from these sources, we arrived at the conclusions presented in this paper.

There are several advantages that result from using an OTEC plant to power a Floating City. The first and perhaps most important advantage is that it may be cheaper to use an OTEC plant, rather than a conventional fossil fuel plant,to power a Floating City. On a Floating City, the cost per installed kilowatt of an oil-fired powerplant would be about $500. Using data from an economic analysis of OTEC plants[1] and the fact that a barrel of oil now costs about $12; we calculated that if the cost per installed kilowatt of the OTEC plant was less thn about $1100, it would be cost-competitive with the aforementioned oil-fired powerplant. The actual cost could easily be less than this, as the cost per installed kilowatt of an OTEC powering a land city has been estimated to be only about $900.

Another possible benifit is that the nutrient-rich discharge water from the OTEC plant could be used to support aquaculture. The cold water pumped up by the OTEC plant for cooling purposes is rich in nutrients used by marine life. This nutrient-rich water could be used to stimulate the growth of phytoplankton, which in turn could nourish larger marine organisms. The produce of this aquaculture could be used as a food source by the city, as well as providing it with a possible export product.

However, there are also disadvantages to powering a Floating City by OTEC. In order to operate, OTEC plants require a warm layer of surface water with cold water beneath. Floating Cities with OTEC plants are therefore limited to ocean areas where this situation is available: tropical waters and warm water currents. Fortunately this still includes all the ocean waters up to about 23° North and South latitude, as well as currents such as the Gulf Stream, which carries warm waters from the Gulf of Mexico past the Eastern seaboard of the United States.

---

[1]Committee on Alternate Energy Sources for Hawaii of the State Advisory Task Force on Energy Policy. 1975. Alternate Energy Sources for Hawaii, Department of Planning and Economic Develepement, State of Hawaii, and the Hawaii Natural Energy Institute, University of Hawaii.

A second disadvantage involves the heating and cooling of the Floating City. If a Floating City were powered by a conventional powerplant, what would otherwise be the waste heat of this powerplant could be used for heating and cooling purposes. With an OTEC plant as a powersource, waste heat for these purposes would not be available. Energy for heating and cooling could be supplied by electricity, but this would increase the size and cost of the powerplant.

Aside from the advantages and disadvantages of the combination of a Floating City and an OTEC plant, there are several obstacles that must be overcome before the structure can be built. However the obstacles identifiable now apply to the systems individually rather than as a whole. Tha obstacles to the construction of OTEC plants are technical; and the obstacles to the construction of Floating Cities are generally legal in nature.

The first obstacle to the construction of OTEC plants involves the problem of bio-fouling and corrosion. The pipes and parts of an OTEC plant (particularly the heat exchangers) will experience to some extent corrosion by seawater and fouling and clogging by sea organisms. The extent to which this will occur has not yet been determined. The other problem with OTEC plants involves their sea-keeping behavior. Because a large proportion of the mass of an OTEC plant is water mass, and this mass is more or less hydrodynamically coupled to the structure, an OTEC plant represents a new type of engineering problem, who's behavior in ocean waves and currents is not yet known.

The first obstacle to the construction of Floating Cities is answering the question of how to define and regulate them. Since Floating Cities are a new type of strucure, few if any laws applying to them have been established. The second obstacle arises because of the size of the Floating City. Since a Floating City would be on the order of 1/2 mile in diameter, it might interfere somewhat with navigation; and some method of handling this satisfactorily must be found. The third obstacle involves the transportation of people and goods to and from the Floating City. If the city is in a high wave area, the usual methods: ferry and barge, could not be used since the waves could sink either one by smashing it into the city. In cases like this another method of transportation must therefore be found.

These obstacles can be overcome of course, with more or less difficulty. At present research is underway at Keahole point, near Kailua-Kona on the island of Hawaii, for the purpose of obtaining data on OTEC plants. Hera research is going on not only on the problems of bio-fouling, corrosion, and seakeeping behvior, but also on ocean conditions, aquaculture, and the socio-economic aspects of OTEC plants. The knowledge from this project willaid in overcoming the obstacles to constructing an OTEC plant. The obstacles appear slightly more formidable in the case of a Floating City, at least they are more complex. The last is an engineering problem, with a different solution for each Floating City, depending on the area where it will be located. The other two problems will have to be brought up at a meeting such as the Third United Nations conference on the Law of the Sea; or if a powerful "International Seabed Resource Authority" was established, these questions could be left to its discretion.

Once these obstacles have been dealt with satisfactorily, the question remains as to whether or not a Floating City should be powered by an OTEC plant. The answer will depend upon a number of factors relating to the relative advantages and disadvantages of using an OTEC plant as the power-source. Obviously, a Floating City cannot be powered by OTEC in those areas where an OTEC plant cannot work. Likewise in areas where the Floating City would require heating, an OTEC plant might not be a viable powersource. However, when the Floating City is situated in an area of mild or warm climate; OTEC becomes the most desirable energy source for a Floating City, because of the cost advantage it holds over oil or gas. In this case, the possibilities for aquaculture become an added benefit of using an OTEC plant as the powersource.

Therefore, we conclude that an OTEC plant can often be a viable powersource for a Floating City, especially in tropical waters such as those surrounding these Hawaiian Islands; and once the aforementioned obstacles have been dealt with succesfully, if a Floating City was ever to be built here in Hawaii, OTEC would be the most desirable means of providing it with power.

BIBLIOGRAPHY

Hagen, A.W. 1975. Thermal Energy From the Sea Park ridge, New Jersey, Noyes Data Corporation.

Lucas, T. 1975. How to Build a Solar Heater Pasadena, California: Ward Ritchie Press.

Eaton, W.W. 1975. Energy Technology Washington D.C.: Energy Research and Developement Administration.

Bathen, K.H. 1975. A Further Evaluation of the Oceanographic Conditions Found off Keahole Point , Hawaii, and the Impact of nearshore Ocean Thermal Energy Conversion plants on Subtropical Hawaiian Waters Department of Ocean Engineering, University of Hawaii. Submitted to Department of Planning and Econimic Developement, State of Hawaii.

Craven, J.P. 1975. "Present and Future Uses of Floating Platforms" Oceanus 19 (1):67-71.

Wolf M. 1974. "solar Energy Utilization by Physical Methods" Science 184 (4134) : 382-386.

Committee on Alternate Energy Sources for Hawaii of the State Advisory Task Force on Energy Policy. 1975. Alternate Energy Sources for Hawaii Department of Planning and Economic Developement, State of Hawaii, and the Hawaii Natural Energy Institute, University of Hawaii.

Department of Planning and Economic Development, State of Hawaii and Hawaii Natural Energy Institute, University of Hawaii. 1976. Hawaii's Natural Energy Resources.

Energy Resources Coordinator, Department of Planning and Economic Development, State of Hawaii. 1976. 1975 Annual Report

Energy Research and Development Administration. 1975. Solar Energy Program

Research Corporation of the University of Hawaii. The Natural Energy Laboratory of Hawaii

TRW, 1975. Ocean Thermal Energy Conversion

Craven, John P. revised 1975. The City and the Sea

OCEAN THERMAL ENERGY CONVERSION AS AN ALTERNATIVE ENERGY SOURCE FOR HAWAII

by Matthew S. Varney, University Laboratory High School

ABSTRACT

One hundred percent of the oil used in Hawaii is imported from foreign countries. Should Hawaii's import sources be cut off, we would be totally deprived of an essential energy source. Ocean Thermal Energy Conversion offers a means whereby Hawaii could become self-sufficient in energy. It is, therefore, important to consider the feasiblity for harnessing this power and environmental impacts associated with OTEC development.

INTRODUCTION

The total fuel consumption for Hawaii is presently 116,000 barrels of crude oil each day and 100% of this oil is imported. Of the 116,000 barrels of crude oil being used in Hawaii, 25% of it is used in the generation of electricity.[1]

Since the oil is 100% imported, if for some reason the O.P.E.C. nations have a disagreement with the U.S., or with Hawaii, and just decide to totally cut off the oil that they are now supplying us, we would be in a very bad situation. People might think that, with all the oil coming from the Alaskan pipeline, we would have no problem getting all the oil we need. The truth is that the oil coming from Alaska is too high in sulfur content to be used in our electrical generators.[2]

In the U.S. there are no other known sources of oil that are really possible to tap. There are some sources in California but, with all the problems they are having, it wouldn't be very likely for us to get large quantities of oil from them. The price of oil can go nowhere but up, and the amount of oil left in the world is relatively low.

During times like these, when fossil fuels are becoming more scarce, it is a good time to find and research possible new sources of energy. One energy source now being studied is Ocean Thermal Energy Conversion (OTEC). This is a process that is designed to get useful work from a heat engine powered by the temperature differences between warm water at the surface and cold, deep seawater.

Here in Hawaii, quite a bit of work is being done with OTEC. On the island of Hawaii there is a proof of concept plant in operation and

---

[1]Howard Wiig, interviewed by Matthew Varney, 3-3-77.

[2]_Ibid_.

extensive studies are being made on it, including its efficiency to total environmental impact studies. If the research does pay off and a good system is developed, the potential for OTEC becoming a major alternate energy source is tremendous.

METHODOLOGY

To research the feasibility of OTEC for Hawaii, I conducted personal interviews, identified books, articles, and reports of major significance, and analyzed major issues. The results of my research are presented here.

FEASIBILITY FOR HARNESSING THIS POWER

In 1926 an OTEC power plan was built using seawater as the working fluid, but the system was operated on land. This, if not the first, was one of the first OTEC power plants. This early OTEC power plant had many problems and was running at very low efficiency so before long it was discontinued.[3]

OTEC is still in the planning and designing stage, but the need for some new way of harnessing an almost inexhaustible source of power increases the support of many organizations. Currently, the National Science Foundation's Division of Research applied to national needs are supporting projects at eight different locations for over 1.3 million dollars.[4]

One of the major problems is getting a design that will work with a reasonable level of efficiency. If you compare the efficiency of an OTEC plant to a conventional coal generation plant, it is clear that the coal plant operates at a 30% efficiency where the OTEC plan has from a 1 to 3%

---

[3]Arthur W. Hagen, Thermal Energy From the Sea, Noyes Data Corporation, 1975, p. 1.

[4]Ibid. p. 1.

efficiency. This low efficiency of an OTEC plant is, however, overshadowed by the free fuel that it would use. Also, not needing to operate at such high temperatures and pressures as a high pressure steam boiler, will bring the operating costs down into competitive ranges with the other systems. The OTEC systems that have been studied so far have had low efficiency levels, but more recent designs are proving to be more efficient.

Another consideration is economic feasibility. At this time there are no real answers because there are no hard facts, only assumptions. There are also additional problems such as the rezoning of large amounts of coastline to permit OTEC development and legal problems, including international regulations governing the use of oceans for ocean-based systems.

DESCRIPTION OF THE OTEC PROCESS

There are two major designs that researchers are working on now: 1) open cycle ocean thermal power plant and 2) closed cycle ocean thermal power plant.

First, the open cycle power plant (Figure 1) uses the fact that water boils at a lower temperature when you decrease the pressure on it. To achieve this in the system, they use what is called a controlled flash evaporation process. This uses the warm ocean surface water at the temperature of approximately 25 C. This water enters the evaporation chamber which air has been removed from causing a partial vacuum. This partial vacuum provides the lowered pressure needed for the water to boil at the lower temperature. The steam that is produced passes through pipes into an expansion turbine to generate electricity and then the steam travels into a condenser cooled by the cold, deep ocean water which is brought in.[5]

---

[5]Arthur W. Hagen, Thermal Energy From the Sea, Noyes Data Corporation, 1975, p. 4.

Second, the closed cycle power plan (Figure 2) also uses seawater but not in the same way as in the open cycle power plant. In a closed cycle power plant they use either ammonia or propane as working fluid. Instead of evaporating the water, the warm seawater is passed over high pressure chambers containing the ammonia or propane causing them to evaporate and then push the generators to create electricity. After pushing the generators the working fluid passes into condensers using again the deep, cold seawater. After the working fluid is condensed, it will go back to the beginning of the system to be used again and again.[6]

When you compare the closed cycle with the open cycle system, you will find that different OTEC experts have different professional opinions. Some feel that the open cycle power plant is more efficient and some feel that the closed cycle power plant is better.

The argument for the open cycle system is as follows. Some experts predict that the open cycle power plant has the potential to produce 25% more power than the other system. The reason for this is that there is possibly a heat loss from the warm seawater when you transfer the heat to the working fluid in the closed cycle system. Also, in the closed cycle system, the component that allows the heat to be exchanged between the seawater and the working fluid is the single most expensive piece of equipment.[7]

Closed cycle systems are also likely to have problems with loss or leakage, the toxic working fluids causing pollution to the ocean.

On the other hand, different experts say that in exchanging the heat from seawater to working fluid, there will be only little or no heat loss. Concerning the possibility of leakage of the working fluid into the ocean, they say that if that ever does happen, the amount of working fluid that is

---

[6]Arthur W. Hagen, Thermal Energy From the Sea, Noyes Data Corporation, 1975, p. 4.

[7]Ibid. p. 6.

Figure 1: Open Cycle Controlled Flash Evaporation process

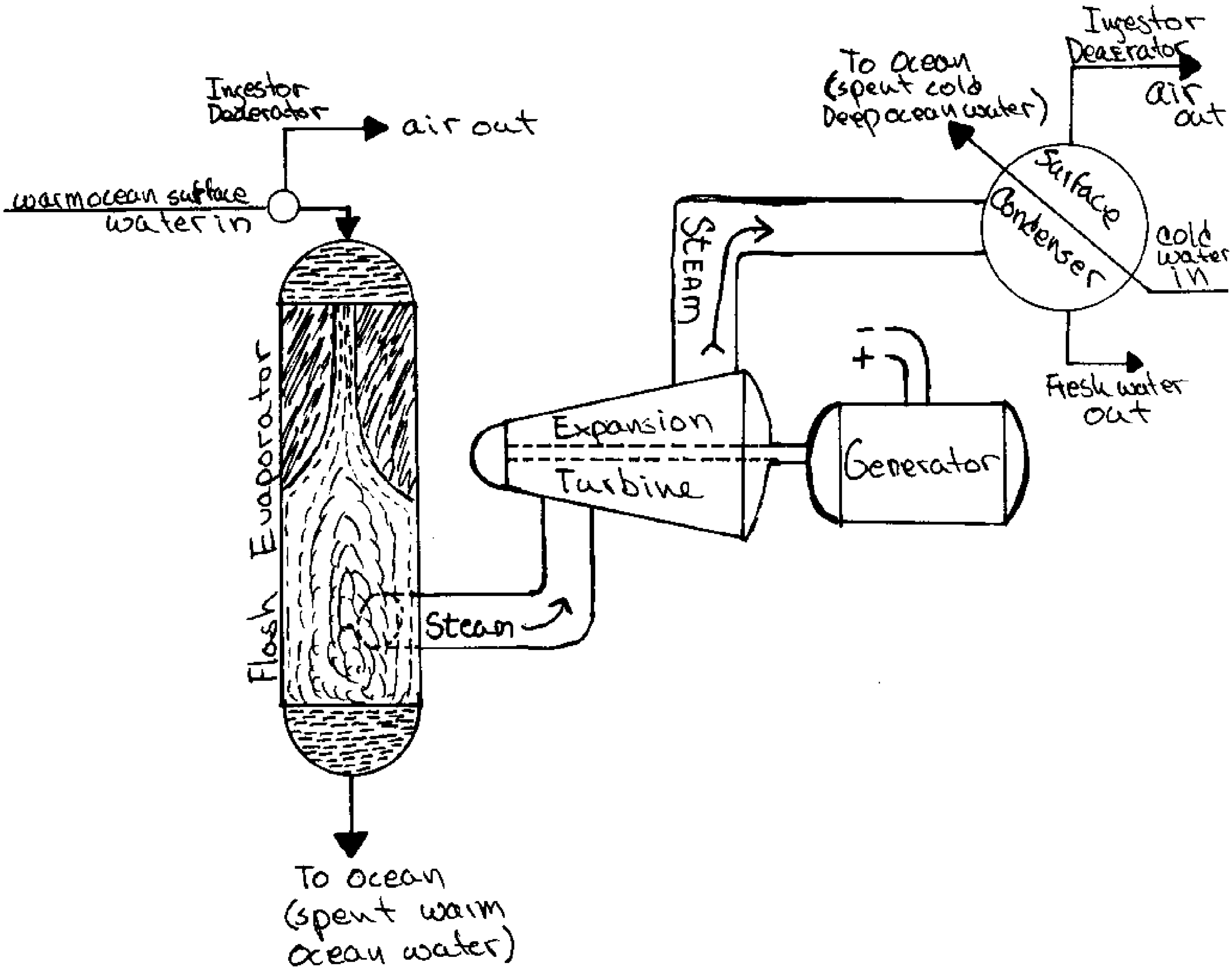
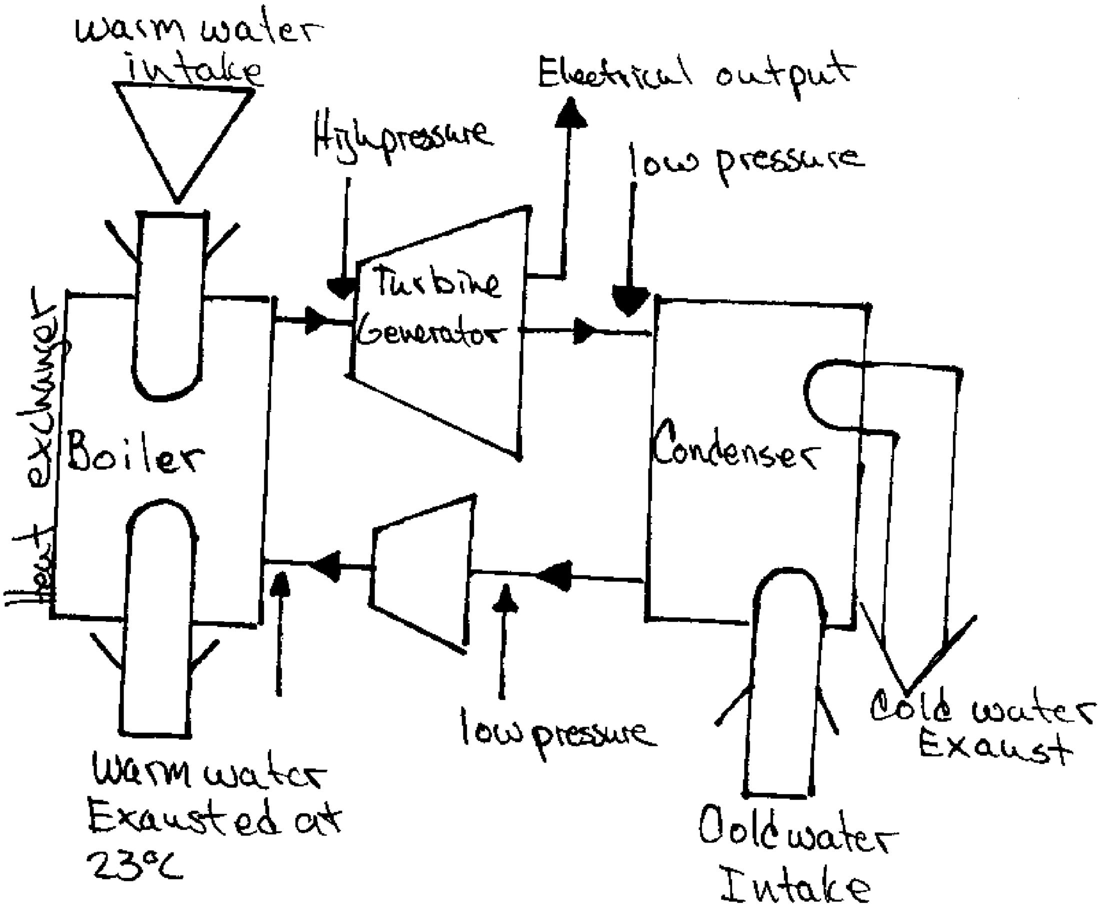


Figure 2: Schematic Diagram of Closed Cycle OTEC power plant



used is not enough to affect the marine environment much or at all. As you can see, the opinions on which system is better are conflicting and will somehow have to be worked out.[8]

OTEC AS AN ALTERNATE ENERGY SOURCE FOR HAWAII

The potential for OTEC to become an alternative energy source for Hawaii is tremendous. When the designers and planners have worked out the problems that they presently have in developing a system that will work efficiently, it will be of great importance to Hawaii and possibly our whole country.

Unless unpredicted environmental problems become apparent, the potential of this system would have several major affects on Hawaii. First, and most important, Hawaii could possibly become energy self sufficient. Second, not having to use oil to drive the electrical generators would lead to the reduction of air pollution. Third, by adding some extra equipment to an OTEC plant you can also produce hydrogen for a very low price.

To be energy self sufficient means that you don't have to import such products as oil to drive the electrical generators. Instead, you would use systems such as OTEC to produce power from the natural resources around us, namely seawater. In addition to producing electricity by the use of OTEC, you can also produce great amounts of hydrogen gas and oxygen gas for a very low cost to be used here in Hawaii and as an export product.[9]

The possibility for Hawaii to become an exporter of hydrogen is good. For this to become a reality, this would have to be done: the electricity which is produced by some of these OTEC plants will be used to electrolize the distilled water produced by an OTEC plant resulting in hydrogen and

---

[8]T. Lucas, How to Build a Solar Heater, Pasadena, California, World Press, 1975.

[9]Collection of Reports: Alternate Energy Sources for Hawaii, 1975; Report of the Task Force on Ocean Thermal Energy Conversion, p. G-18, appendix G.

oxygen gas. Then the gas can be stored or piped to shore in a reasonable fashion.

Hawaii is now producing 1,250 megawatts of electrical power. It would only take slightly more than three 400 megawatt OTEC power plants to equal the total electrical output of the State. Also, for Hawaii to produce enough hydrogen to use and export would only take five additional OTEC power plants. Therefore, it would take approximately eight OTEC power plants for Hawaii to become energy self sufficient. Take those power plants and spread them throughout the island chain and it wouldn't affect the amount of open waters for transportation or recreation to be a problem.

Hawaii does have very good conditions to support OTEC. The weather is relatively warm and needless to say there are many sites which would suit the needs of OTEC plants.

ENVIRONMENTAL IMPACT

For any type of project that is being proposed, whether on land or in the ocean, I feel as many other people do, that there should be a great deal of thought put into the environmental impacts of the proposed development. In all stages of the development of OTEC, there have been extensive studies and papers done on the environmental impacts of the systems.

At present there are two major environmental impacts to be considered and a few other smaller considerations. The first major impact would only be considered if the OTEC concept was applied on a massive scale. The problem would be its affect on the ocean's thermal balance. To implement such a massive use of OTEC that would affect the ocean's thermal balance would be quite unlikely. If it did happen in such proportions, the resulting cooler surface waters would absorb more of the solar radiation so the temperature of the oceanic surface waters would be affected little or not at all.[10]

The second major possible environmental impact would be the upwelling of all the deep-sea, cold nutrient-rich water used in the condensers. This is a problem no matter what the scale of application. The nutrient-rich water, if exhausted to ocean surface, could produce uncontrolled but possibly environmentally acceptable biostimulation. Instead of this being an adverse impact, it could possibly prove to be another advantage of OTEC. If the cooling waters coming off the condensers are then channeled or piped into an on-shore lagoon or pond, it would stimulate the photosynthetic process by providing the necessary nutrients. This might possibly create a good environment for an aquaculture site. Another less important impact is the possible affects of leakage of the working fluids from a closed cycle power plant.[11]

CONCLUSIONS

Ocean thermal conversion is still in the developmental stages, but already we can see how useful it will be in the future. When the developers do find a design that fits all the criteria and put it to use, it will become even more apparent how important it is.

Right now the whole world is wondering what will happen when we finally do use up all the fossil fuels. We are supposed to be having an energy crisis now. This may be true as far as fossil fuels are concerned, but people don't realize that there are alternate energy sources. For instance, to have an idea of how much energy there is available, consider that in fifteen minutes the earth receives enough solar energy from the sun to equal the amount of energy used worldwide in the form of fossil fuel and nuclear fuels each day.

---

[10] Collection of Reports: Alternate Energy Sources for Hawaii, 1975; Report of the Task Force on Ocean Thermal Energy Conversion, p. G-10, appendix G.

[11] Ibid. p. G-11.

Further, in less than four days the earth intercepts the amount of energy equal to all of the earth's fossil fuel reserves.[12]

The only problem now is to find a way to tap this immense source of power. One way that can be applied in the near future is ocean thermal energy conversion. It is only a start toward tapping the source, but it is a good one.

Whether or not the energy crisis is real or being staged by the oil companies and the oil-rich nations isn't the question. What really should be considered is that sooner or later there will be a real crisis on our hands. By then, if we do not have an alternate energy source such as OTEC we truly will be in trouble.

---

[12]Hagen, p. 15.

BIBLIOGRAPHY

Alternate Energy Sources for Hawaii. A collection of reports, State of Hawaii, Hawaii National Energy Institute, University of Hawaii, and Department of Planning and Economic Development, 1975.

Bathen, Karl H. Report on Oceanographic Conditions and the Environmental Impacts of Near Shore OTEC Plants. Submitted to Department of Planning and Economic Development, Hawaii, 1975.

Hawaii's Natural Energy Resources, Hawaii Natural Energy Institute, University of Hawaii, and Department of Planning and Economic Development, State of Hawaii, 1976.

Hagen, Arthur W. Thermal Energy from the Sea. New Jersey: Noyes Data Corporation, 1975.

Lucas, T. How to Build a Solar Heater. Pasadena, California: World Press, 1975.

EUREKA! AN ALTERNATE ENERGY DEVICE

by Robert S. Williams, Pahoa High School

ABSTRACT

Soon we will run out of petroleum. When we do man will be hard pressed for energy. A few, with forsight, have concentrated their efforts toward alternate energy sources. Sooner or later man will turn to the sea for his needs.

In this paper, I will explain a device which uses wave, wind, and tide power. This device is simple and inexpensive. It proves much more practical than other plans for wave and tide energy devices. This device should prove to be of great interest to anyone who is concerned with the idea of erecting huge multi-million dollar projects now proposed, and would like to see a less expensive and smaller, less obtrusive, energy device.

INTRODUCTION

The State of Hawaii, and most of the United States, relies on some form of fossil fuel for their main source of energy. For years the shortage and the inevitable total lack of oil and coal has been pressing on mankind to find ways of harnessing inexaustable energy sources. Sources such as the wind, solar, bioconversion, and ocean waves, currents, and tides are the main fields of research and development. Hawaii is the most vulnerable of all the fifty states to dislocations in the global market because of the fact that we are nearly totally dependent on sea-born petroleum.

Two-thirds of the earth's surface is covered by water. The land space is growing short. All of the current developments on harnessing wave energy are both quite large and extremely expensive. The Issac's wave pump is the only simple design for wave energy capture. See Figure 1.

STATEMENT OF PROBLEM

Present tide developments are expensive and they block ways to sea traffic, unless they use expensive locks. My design is a marriage of wind, wave and tide power in a simple, inexpensive, and practical package.

We have great need for such a design. Harnessing the available sea energy and resources may be our only hope for a world whose demands increases as the supply decreases.

DISCUSSION

For many years, I have been interested in alternate energy. We all, at one time or another, have been intrigued with the idea of 'free energy' from a windmill or a solar collector. I read many reports about developments in these fields. Tidal and wave energy interested me also, because of the present need for a simple inexpensive way to capture that energy. I observed that all the present technology were modification on a general dam system. They would dam a bay and let the rise and fall of the tide turn the turbines in the dam. This system, as I mentioned before, has two bad points. It is very expensive. For example, the capital costs for a double-effect tidal power unit in the Bay of Fundy was $660.1 million. Generally they range anywhere from $350 million to a high of $660+ million. The second bad point, is that most sizable bays see considerable traffic. With the dam systems, in some cases also expensive fish ladders must be provided.

The first complaint also applies to present technology in the way of wave energy devices. They either take up a great deal of our shorline, or they take up a great deal of space at sea. The one exception is the Issac's wave pump, which is not very efficient and not worth considering as an energy source in itself.

I looked at the Issac's wave pump and noticed similarities in design, but this was in supportive research, and I arrived at my concept independently. In my energy system, I used a floating housing for the generator, the shaft of which was geared with two ratcheted gears and another connected to one to reverse the action. On the sea bottom I placed a concrete block and out from that, stretching upward, I placed two thin steel beams. These beams have teeth on them so as to engage with the gears. Thus on the upward and downward motion of the waves and tide, the generator would float, while the beams, being stationary, would turn the shaft.

The design is illustrated in Figure 2.

As you can see gear 2 reverses the action. Thus generating energy on the up and the down motions.

The float housing size would be regulated by the weight of the generator and gears, plus the drag of the beams. Plastic could be used in the gears and float housing to minimize this to an extent.

On top of the float housing I added a windmill of the darrius or 'egg-beater' type to add to the eficiency of the float. Many parts, including the blades, could be made of plastic instead of aluminum to minimize weight and maintaince cost.

The darrius windmill is a vertical windmill marked by increased efficiency over our convehtional types. No vane is needed and no gearbox to power the windmill shaft. With the added windmill, the generator unit would look like **a buoy** . This way both vertical and horizontal energies are captured. This type of device would be much less expensive than other projects. But as far as a cost per kilowatt hour, I would not be able to determine this until such time that I would be able to obtain funds to develop a prototype.

CONCLUSIONS AND RECOMMENDATIONS

The result of my invention would be unobtrusive and would have very little environmental impact of a negative type. It would save sea traffic the trouble of locks and migrating fish the incovience of fish ladders. Shoreline impact would be low, the only change would be that of one cable leading up the beach.

The result would be clean, safe energy. The cost would be low, and the unit would be adaptable to almost any size. The local conditions would determine the size. With the Trade winds in Hawaii, an almost constant output from the windmill could be expected. Plus, most of the time there are sizable swells on the open sea. The tides rise and lower constantly or at a predictable rate, so a constant source is imminent there.

The committee on Alternate Energy Scources for Hawaii of the State Advisory Task Foree on Energy Policy, recommended, in a 1975 report, that a moderate State interest in adaptive technology be taken in wave and tide energy. The same committee placed a high recommendation on the use of wind energy. So it can be clearly seen that it is imparative that a practical system be developed.

In conclusion, I think several further suggestions are in order. I suggest that most of the system be made from plastic to resist corrosion, and be lighter in weight. I suggest that an anchor cord be added to keep it from floating away during a stom. The tower for the windmill should be made of plastic and reinforeed with aluminum, and should be made to collapse in high winds to avoid damage to the main unit. Then after a storm the unit could be reset manually.

Eureka ! I can see my device as being a practical means of meeting Hawaii's future energy needs.

Committee on Alternate Energy Sources for Hawaii of the State Advisory Task Force on Energy Policy, Alternate Energy Sources for Hawaii, Hawaii Natural Energy Institute. University of Hawaii, February 1975.

Stephr. "Eggbeater Windmill," Popular Science, May, 1975.

Wade, Gary. Homegrown Energy for the Home and Homestead, Oliver Press, Willits, California, 1974.

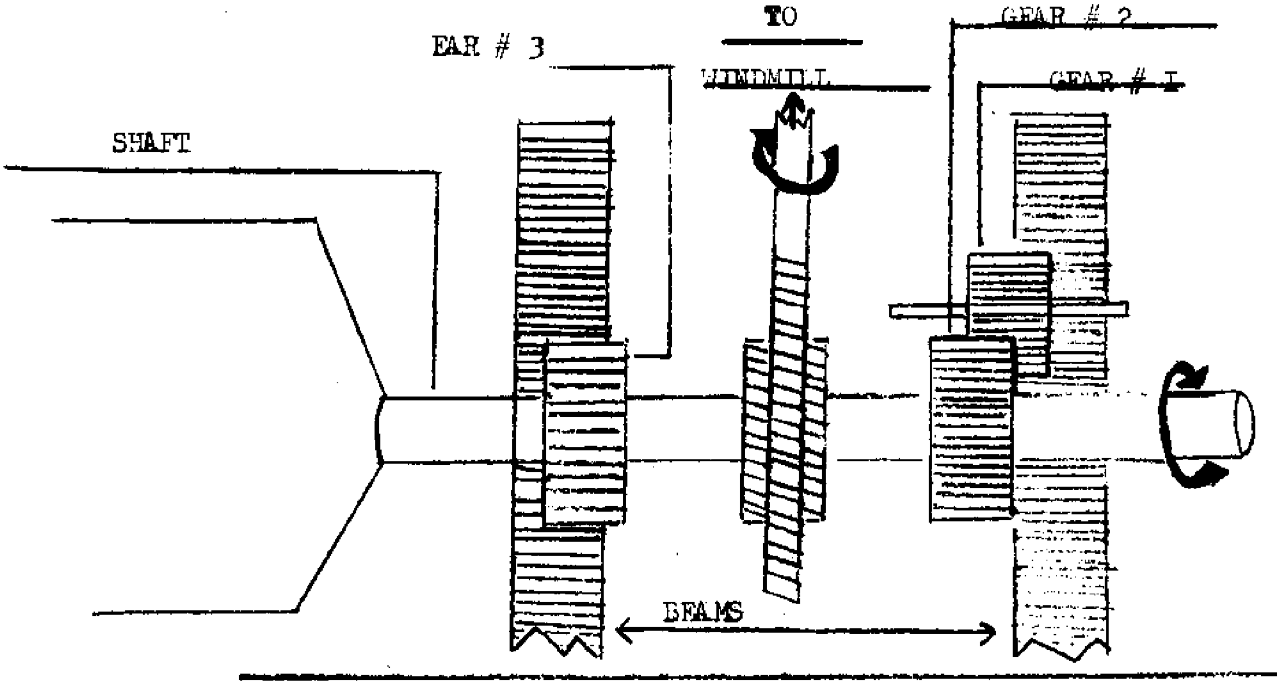


FIGURE 2. THE DESIGN

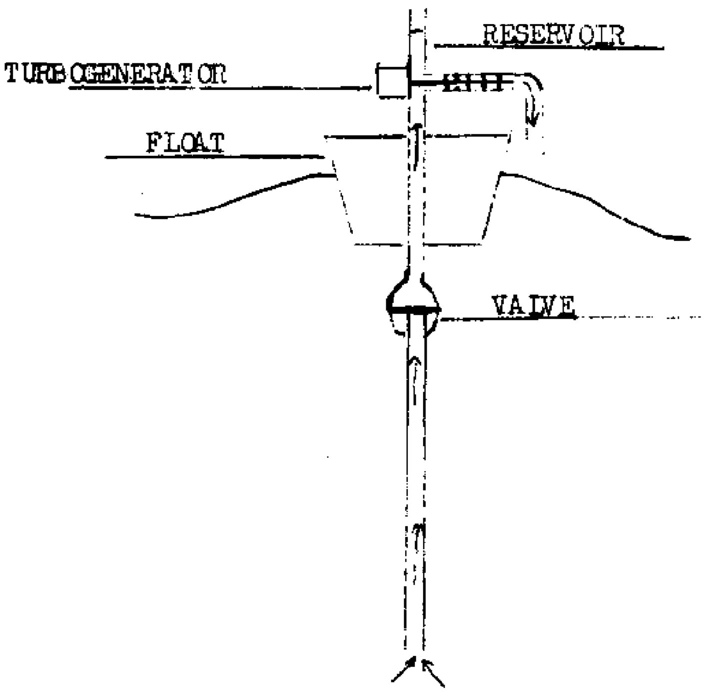


FIGURE I. ISSAC'S WAVE PUMP

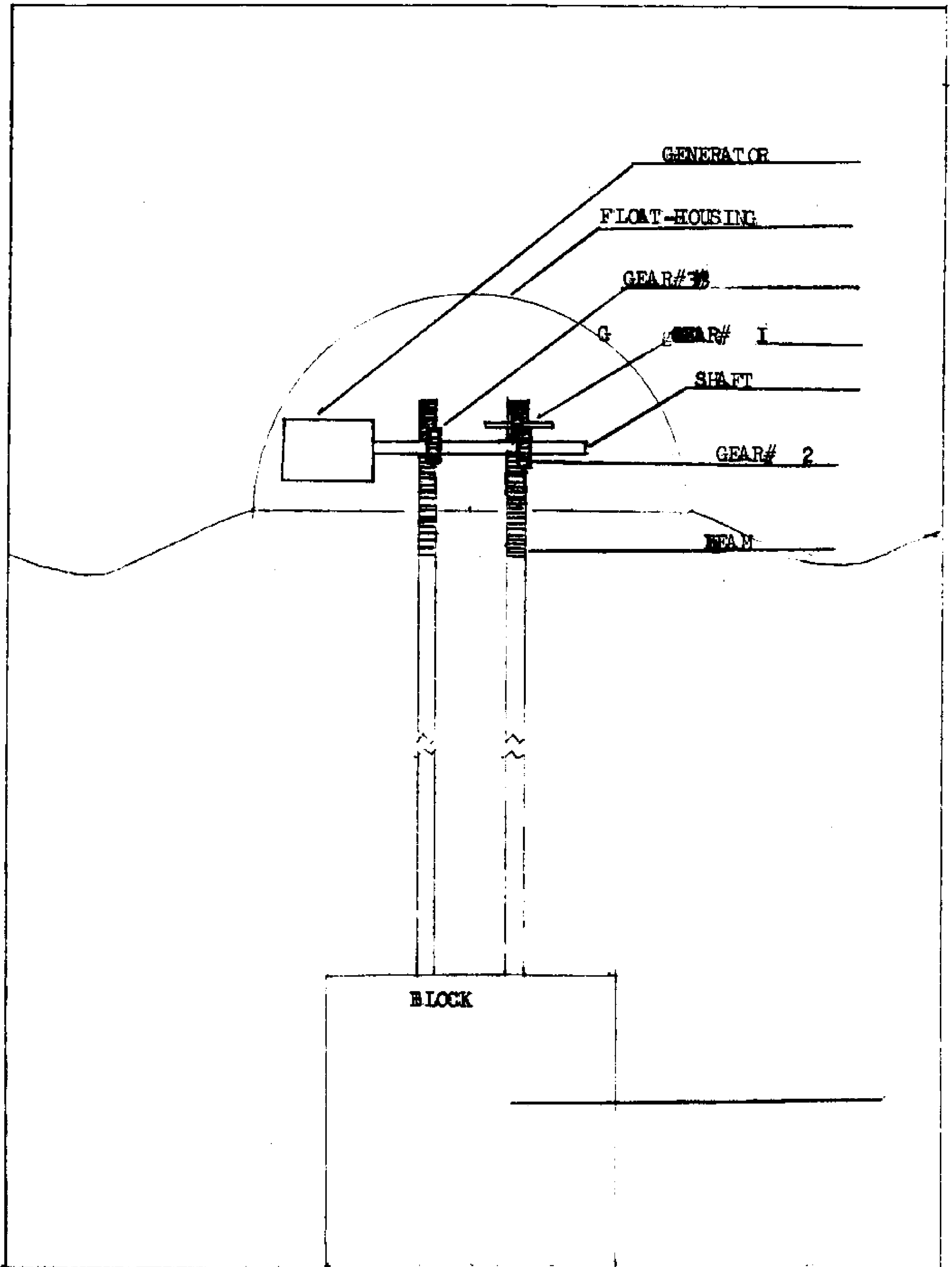


FIGURE 3 COMPLETE DESIGN

MARINE RESOURCES:
FISHERIES MANAGEMENT

FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976: PROBLEMS AND IMPLICATIONS

by Randall T. Chun and John K. Ogoshi, McKinley High School

ABSTRACT

This paper explores the implications of the recent establishment of a 200 mile Fishery Conservation Zone around the Hawaiian Islands. This is a result of the Fishery Conservation and Management Act of 1976, which went into effect on March 1, 1977. Through research, it was found that Hawaii's fishery resources are underutilized. The Act will allow Hawaii to expand its use of these resources and will also give Hawaii a greater supply of resources to draw upon in the future. The management plans which are a result of the Act limit the foreign catch of armorheads and alfonsins in the Conservation Zone to 2,000 metric tons and do not allow any foreign harvesting of coral. These restrictions, which conserve the resources for future use by the local industries, are not expected to cause Hawaii any political difficulties. The only potential source of difficulty at present would be the possible enactment of a management plan for billfish. This would affect the Japanese tuna catch within the Conservation Zone and probably lead to protest by Japanese fishing associations.

INTRODUCTION

The Fishery Management and Conservation Act of 1976 gives the United States exclusive management authority over all fishing resources, with the exception of highly migratory species, within 200 nautical miles from the shoreline. Within this fishery conservation zone, the United States has the right to determine the amount of fish that foreign vessels may catch and also decide what nations may fish in the area. Also regulated under this Act is the harvesting of various species of coral, crustaceans, mollusks, and sponges by foreign nations.

The Act gives American fishermen first preference in fishing the areas within the fishery conservation zone. Foreign nations are allowed to catch only that portion of the optimum yield of a fishery that is not harvested by American fishermen.

The optimum yield for each species is determined as part of a fishery management plan which is drawn up by the Regional Fishery Management Council in whose area the species is found. In determining the optimum yield, a number of economic, social ecological and biological factors are considered, to provide the greatest overall benefit, with particular attention to food production and recreational opportunities.

Management plans are formulated by each Regional Council for the individual fish species particular to the region. The United States is divided into eight Regional Councils, with Hawaii belonging to the Western Pacific Council, along with American Samoa and Guam.

These councils are the basic organization for management and conservation of America's fisheries within the 200 mile zone. Aside from developing fishery management plans, they must also submit periodic reports to the Secretary of Commerce and review and revise assessments of optimum yield and allowable foreign fishing.

The Regional Councils also decide the opening and closing of fishing seasons, what grounds can be closed to fishing, and the type of fishing gear that can be used. The restrictions on gear can prevent the harvesting of immature or illegal species through the regulation of net size and the depth and speed of the tow.

The quotas set by the Act are not expected to limit or reduce the catches by American fishermen but may limit the catches made by foreign fishermen. It is left to the Regional Councils to estimate what portion of the harvestable fishing stocks Americans are not using. This surplus is then made available to foreign fishermen. Generally, foreign fishermen will be allowed to catch species not caught by American fishermen. A result of this is that in Hawaii, foreign fishermen will be able to fish for armorheads (Pentaceros richardsoni) and alfonsins (Berys splendens) up to a quota of 2,000 metric tons since the fishes are not caught by American fishermen. Foreign fishermen are restricted from harvesting precious coral within the 200 mile zone around Hawaii since the coral is of importance to Hawaii's own coral industry.

In addition to adhering to the established quotas, foreign fishermen will also be required to pay license fees, and keep detailed records of each use of their fishing gear -- recording the position, speed, the species caught and the tonnage of the catch. The foreign vessels must also allow boarding by the U. S. Coast Guard for inspection and enforcement of regulations and may also be required to carry an American observer on board.

THE LOCAL FISHING INDUSTRY

Commercial fishing in Hawaii is an industry that has not been exploited to the fullest. In 1973, Hawaii's landings by weight totalled 7,026 tons, placing it twenty-second among the fifty states and twentieth in the value of its catch ($6.1 million).

Most of the commercial fishing is done for tuna. In the fiscal year ending June 30, 1975, skipjack tuna comprised 10,261,257 pounds and other species of tuna 1,460,146 pounds, making up 81 percent of Hawaii's commercial landings.

A large part of the resources that are within the range of part of Hawaii's existing high seas tuna fleet are being caught by foreign longline fishermen. Also, fishery scientists feel that the skipjack tuna resources in the central Pacific are underutilized. At the present time, 350,000 - 400,000 tons of skipjack are being caught annually in the Pacific and it is felt that this catch can be doubled without overfishing the stocks.

Because of this, the future of Hawaii's fishing industry may lie in the expansion of the existing high seas tuna fleet and the expansion of the markets serving them, while at the same time developing new fishing grounds, such as the Leeward Islands of the Hawaiian Archipelego.

The adoption of the 200 mile Fishery Conservation Zone will increase the opportunity for Hawaii's commercial fishermen by extending their fishing area and preserving future resources. However, the Act is not expected to benefit tuna fishermen greatly since tuna is a migratory species and is not regulated by the Act. Hawaii tuna fishermen will still have to compete with foreign fishermen who will not be limited by catch restrictions.

FOREIGN FISHING AND THE PRELIMINARY MANAGEMENT PLAN FOR ARMORHEADS AND ALFONSINS

The foreign fishing within the conservation zone occurs mainly around the Hancock Seamount, located just inside the 200 mile limit northwest of the Northwestern Hawaiian Islands. Here, foreign fishermen (the majority from Japan and Russia) fish for armorheads and alfonsins, which are not presently harvested by American fishermen. Armorheads make up over 90 percent of the foreign trawl catches on the seamount, with alfonsins being only a small part of the catch. The fishing by bottom longlining is focused on alfonsins.

The bulk of the Japanese and Russian fishing for armorheads and alfonsins is done outside the Fishery Conservation Zone around the seamounts northwest of the Midway Islands.

At any one time, about 5-15 Soviet and Japanese stern trawlers fish the seamounts northwest of Midway while about 16 Japanese vessels engage in bottom longlining off Midway. The annual combined catch of these 16 Japanese vessels is estimated at not more than 4,000 metric tons, which consist mostly of alfonsin. About 500 tons of this catch is caught within the U.S. Fishery Conservation Zone.

The annual combined catch of Japanese trawlers fishing the seamounts northwest of Midway was 19,957 metric tons in 1975, which consisted mostly of armorheads. About 10 percent of this was caught within the Fishery Conservation Zone.

The total annual harvest of armorheads and alfonsins (of which the armorheads comprise over 80 percent) by Soviet and Japanese vessels from the entire seamount chain is estimated as between 10,000 and 50,000 metric tons. There are no figures as to the amount of this that is caught within the U.S. Conservation Zone although general estimates of Japanese fishing alone have been given.

The Preliminary Fishery Management Plan for armorheads and alfonsins limits the total foreign catch of these fish to 2,000 metric tons per year in the Hancock Seamount area and other seamounts west of the 180 degree meridian. No foreign fishing would be allowed elsewhere. The total effort would be limited to 50 vessel days and vessels would be subject to all regulations of the Fishery

Conservation Act.

The 2,000 metric ton quota is designed to allow potential U.S. fishermen for armorheads and alfonsins to undertake future operations in the area under the best possible circumstances (with stock levels unreduced by foreign competitors). If a 10,000 metric ton annual harvest of armorheads could be sustained in the Hancock Seamount area, it is speculated that an annual catch worth $6,000,000 could be taken by U.S. fishermen.

The Act also allows U.S. scientists to study fishery resources in the Northwestern Hawaiian Islands while they are in a virgin state since foreign fishing is limited to the seamount area.

Also, by examining the data from the allowable foreign fishing operations on the seamount, U.S. scientists would be able to assess the fishery stocks potential, as well as to keep a record on the amount of the stock being harvested.

THE PRELIMINARY MANAGEMENT PLAN FOR BILLFISH

As of March 9, 1977, the National Marine Fisheries Service was still in the process of writing up a preliminary fishery management plan for billfish. If this plan is implemented, Japanese fishermen feel the quota on billfish would limit their tuna catch within the conservation zone.

This would occur because billfish is not considered a highly migratory species by the act and therefore is not exempt from regulation. A quota on billfish, which is an incidental catch of Japanese fishermen, would then limit the amount of tuna that could be caught, even though tuna is defined as a highly migratory species and is not regulated by the act.

If the management plan for billfish does go into effect, it will probably result in protest by Japanese fishing associations since approximately 2 percent of the tuna Japan catches in the Pacific is caught in the 200 mile fishery conservation zone around Hawaii.

THE HAWAIIAN CORAL INDUSTRY AND THE PRELIMINARY MANAGEMENT PLAN FOR CORAL

The Hawaiian coral industry makes use of three different kinds of precious coral - red or pink coral, gold coral, and bamboo coral. Another type of coral - black coral, is also harvested but since there is no foreign interest in harvesting black coral and since the known beds occur primarily within the territorial sea, this type will not be considered.

Six beds of pink, gold, and bamboo coral have been located within the Hawaiian Archipelago. Of these six, only the bed off Makapuu, Oahu has been extensively surveyed and it supports the only existing commercial fishery. Other unexplored banks in the Hawaiian Archipelago are thought to support precious coral stocks.

In 1975, at least 500 people were employed in various stages of the production of coral jewelry. In that year, the gross retail sales of the Hawaiian coral industry were about $11 million, which is an increase of three over the retail sales of 1972. This is partly due to the development of Hawaii's own coral resources - which make the local industry less dependent on foreign sources of supply.

To continue to grow and prosper, the local industry must have access to a reliable and controllable supply of raw material. The coral bed at Makapuu is thought to be just a fraction of the commercially productive coral resources of the Hawaiian Archipelago.

The preliminary fishery management plan for Hawaiian corals preserve these resources by prohibiting the foreign harvest of precious corals from any bed in the 200 mile conservation zone. Foreign vessels will be allowed to harvest coral only when the bed has been surveyed and scientifically assessed, and the surplus yield that will be available has been determined.

FOREIGN HARVESTING OF CORAL

Although at the present, there is no documented foreign harvesting of precious coral within Hawaii's 200 mile conservation zone, Soviet and Japanese trawlers may be indirectly harvesting coral and damaging coral beds in their fishing for bottom fishes - armorheads and alfonsins. The effects of this on the domestic coral fishery are unknown and being studied as part of the research being done on the commercial harvesting of coral.

LAW ENFORCEMENT BY LOCAL COAST GUARD

As of March 1, 1977, the United States Coast Guard and the National Marine Fisheries Service are in charge of enforcing law in over 2.5 million square miles of coastal waters off the United States. Because of this vast amount of space to patrol and only a limited number of aircraft and ships to patrol it with, the Hawaiian Coast Guard is concentrating its main efforts to patrol "active fishing areas" and only randomly spot-checking the less fished areas.

In order to accomodate the patrolling of the newly acquired area the United States Coast Guard is reactivating three old Coast Guard cutters and retaining a fourth on active duty, even though it was scheduled to be decommissioned. Also reactivated are four retired Defense Department planes and the last five spare short-range helicopters have been put into service. The Coast Guard department in charge of law enforcement in Hawaiian waters consists of three C-130 planes, two high-endurance cutters, two buoy tenders and three patrol boats. Areas are patrolled randomly approximately three times per month. However this figure will increase when more fishing boats arrive.

All foreign fishing vessels are required to possess a fishing permit for a specific area in which to fish. As of this writing only two Japanese vessels and two Russian vessels have applied for a permit. Since the total amount of fish allocated to foreign fishermen is 2,000 metric tons, each ship has been allowed to fish for twenty-five vessel days or to catch 500 metric tons of fish, whichever comes first.

U. S. observers must be allowed to board any foreign vessel to assure that rules and regulations are being complied with. The observers are trained to be able to judge the amount of fish that are being taken. They report any violations they may suspect. Violations of the law includes fishing without a permit, harvesting more fish than permitted, fishing for too many days and fishing in areas other than the area designated by the permit. Measures of enforcement range from issuing of citations for minor crimes to seizure of the vessel for major violations.

Lieutenant Scott L. Anderson of the Coast Guard feels that there are few problems concerning the law in Hawaii. So far all foreign fishing operations have been following procedures and very few have been seen in local waters.

CONCLUSION

Research revealed that Hawaii's fishery resources are presently underutilized and that there are many opportunities for the expansion of Hawaii's fishing and related operations.

The establishment of the Fishery Conservation Zone gives the local fishing and coral industries great potential for further development. The enactment of the Management Act has created the possibility of local fishing for pelagic armorheads and alfonsins, which are presently not harvested by American fishermen. The coral industry will also benefit by the restrictions on foreign coral harvesting within the conservation zone. The potential supply of coral within the zone will enable the local industry to remain independent of foreign sources.

The Preliminary Fishery Management Plan for armorheads and alfonsins (which make up the bulk of foreign catches within Hawaii's 200 mile conservation zone) limits foreign harvesting of these fish to a total of 2,000 metric tons. While this is below the current catch of Japanese fishing vessels alone, the quota is not expected to cause any political problems. The only source of difficulty at present is the proposed Fishery Management Plan for Billfish. If put into effect, the plan would limit Japanese tuna fishing operations within the fishery zone, and probably result in protest from Japanese fishing associations.

The passing of the Conservation Act will be very beneficial to the State of Hawaii. The Act will conserve Hawaii's fishery resources by protecting them from over-exploitation and also provides Hawaii with the opportunity to further develop its maritime industries.

BIBLIOGRAPHY

Grigg, Richard W., Fishery Management of Precious and Stony Corals in Hawaii, UNIHI-SEAGRANT-TR-77-03 Contribution No. 490, September 1976.

Fishery Conservation and Management Act of 1976, reprinted by the Sea Grant College Program, University of Hawaii, July 1976.

Seamount Groundfish Fishery Resources (Pelagi Armorheads and Alfonsins), Final Environmental Impact Statement/Preliminary Fishery Management Plan, U. S. Department of Commerce, January 1977.

Precious Corals, Final Environmental Impact Statement/Preliminary Fishery Management Plan, U. S. Department of Commerce, January 1977.

Hawaii and the Sea - 1974, Prepared for the Governor's Advisory Committee on Science and Technology, State of Hawaii Department of Planning and Economic Development, 1974.

Steinhart, Peter, 200 Mile Zone for Fishing Set, The Sunday Star Bulletin and Advertiser, July 27, 1977.

Bale, John L., Jr., Fisheries and the State of Hawaii Input to the National Fisheries Plan, Working Paper No. 4, Sea Grant College Program, February 1975

Western Pacific Regional Fishery Management Council, Minutes of the December 15 Session, Minutes of the December 16 Session, Minutes of the February 1 Session, Minutes of the February 3 Session.

Fishery Conservation and Management Act of 1976, Report of the Committee of Conference on H. R. 200, U. S. Government Printing Office, Washington, March 24, 1976.

Interviews with:

Richard Shomura, Director of Honolulu Lab, National Marine Fisheries
Robert T. B. Iversen, National Marine Fisheries
Mr. Baba, Consulate General of Japan
Lieutenant Scott L. Anderson, Intelligence and Law Enforcement Department of U. S. Coast Guard

SHARK FISHERIES: A NEW HAWAIIAN INDUSTRY?

by Heidi K. Ranta, Kalaheo High School

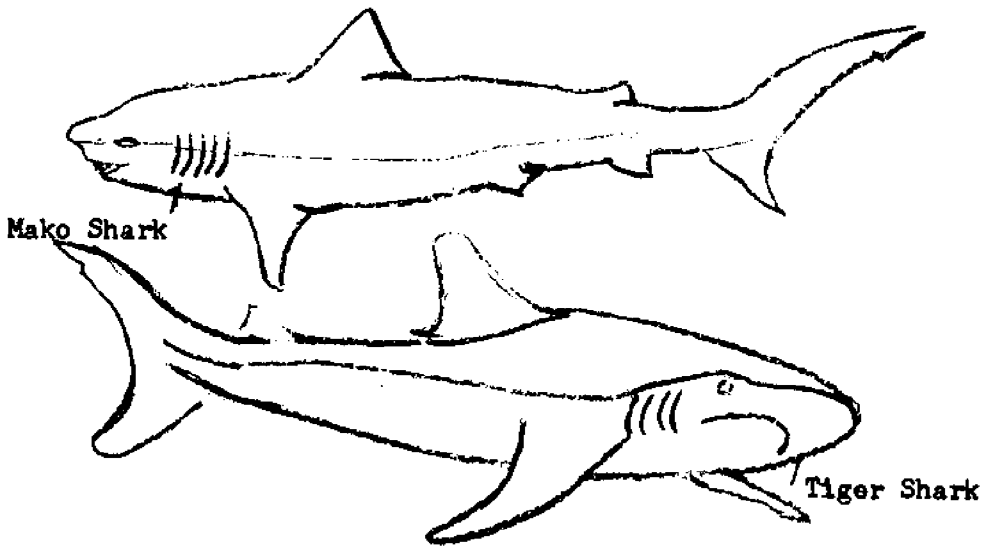
Sharks have ingabited oceans of the world for over 250 million years. Man remembers them mostly as dangers of the deep. The facts are that more people die as a result of mosquito bites than from shark attacks. Because of these myths, though, sharks are left to live out their lives with little opposition from man.

Over 250 species of sharks are known to man. They inhabit almost all oceans and seas of the world. Yet, very little is known about their lives or how they survive. Sharks have no bones in their bodies, only a stiff cartiledge . Organs are loosely fixed and a shark could literally beat himself to death. Strong jaws and a thick stomach allow him to digest almost anything.

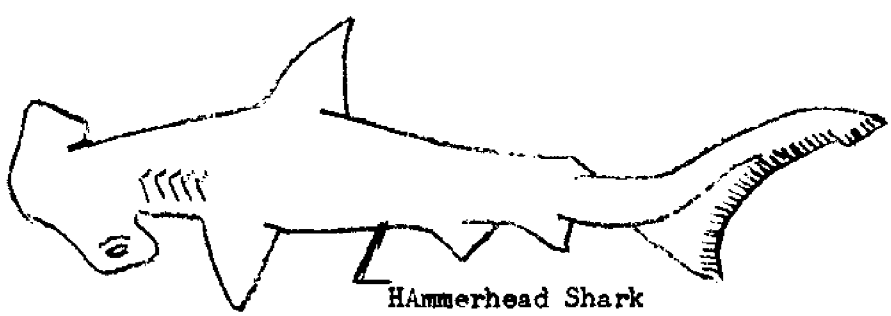
As a commercial product, the shark is valuable. Every part of his body can serve a purpose for man. Sharkskin could be used as a tough leather in making shoes, belts or the handle to suitcases. Teeth and jaws are valuable in the tourist industry, they are used for making pendants, earings, and other jewelry as well as being souveniers. Fins have long been used in Japan for making shark-fin soup. The shark-liver is an excellent source of Vitamin A and oil which can be used for lubrication. Steaks can be had from the shark flesh and are eaten fresh, smoked or dry-salted. British fish and chips are often made of one species of shark sold under the name of flack or rock salmon. Left over entrails can be used as bait for other sharks.

Cammercially, sharks can be caught in numbers by using a long-line method. This consists of steel cables with hooks along the ocean bottom, at the surface or hanging perpendicularly in the water. One-eighth inch

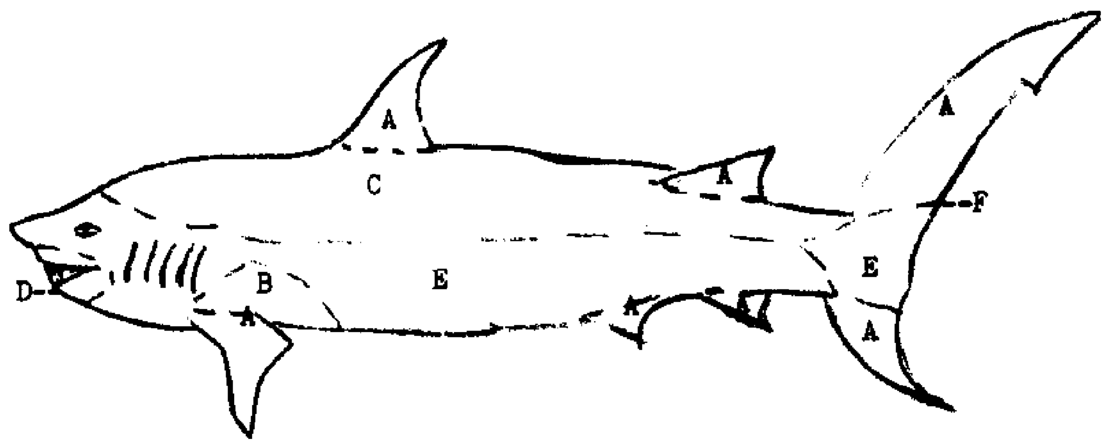
SHARK SPECIES IN HAWAIIAN WATERS



The Mako, Tiger and/or Hammerhead Sharks, as well as other species of shark found in Hawaiian waters could create a new industry for Hawaii. Shark Fisheries based in Honolulu would supply jobs, anew food source and other products to Hawaii's economy.



USES FOR THE SHARK



A: fins for soup
B: liver-oil & Vitamin A source
C: Steaks, edible
D: Jaws and Teeth, tourist industry
E: Entrails, shark bait
F: Sharkskin, leather

steel cable is used and 14/0 mustad hooks, as many as one hundred or more at a time for each line.

Bait for catching sharks is easy to acquire. Aku has been known to work best, but this can be expensive. Shark entrails or meat comes next in line for effective bait. EEl or miscellaneous fish may also be used, however shark is the most economical.

World hunger and a food shortage is being preached throughout the world today. Fishermen could possibly be able to provide more food without the shark as a constant competitor. Sharks are present in our waters and could not easily be eliminated. At present only about 0.5 percent of the world's commercial fisheries catch consist of shark. A solution is to use the shark as a natural resource and supplement to the world's food supply. Shark meat is considered one of the best cuts of fish by some, and methods of preparation are numerous.

To begin shark fisheries in Hawaii would provide many new fobs. This would aid unemployment problems and create an expanding business. Fishermen would be needed to catch sharks and bring them in to dock, there, more jobs could be created in processing and packaging plants. The tourist industry would also benefit from a shark fishery with teeth, jaws and shark fishing charters. Every part of the shark can be utilized in some way to make this a profitable industry.

As a supplement to Hawaii's food supply, the shark need not be imported and therefore prices for shark products would be reasonable. The best shark fishing areas are in southern Oahu, so the industry could easily be based in Honolulu where sales, processing and profits would remain in Hawaii.

Sharks have inhabited our oceans for centuries. They have been feared and worshipped in Hawaii. If shark fisheries were established in Hawaii, man could benefit greatly from their present competitor - the shark.

BIBLIOGRAPHY

1. Butler, Jean Campbell. Danger--Shark. Little, Brown and Company, Boston. 1964. pp 237.
2. Lineaweaver, Thomas. Natural History of Sharks. J. B. Lippincott Co. pp 256.
3. Ommanney, F. D., and Editors of Time-Life Books. The Fishes. Time-Life Books, New York. 1970. pp 192.
4. Springer, Stewart. "Shark". Encyclopedia Americana, VOL. 24. American Corporation, U.S.A. 1976.
5. "Shark". Compton's Encyclopedia, VOL. 22, p 144. F. E. Compton Co., University of Chicago. 1974.
6. Excerpts from the final report of 'The 1971 Shark Control and Research Program. Hawaii. (vessel: Easy Rider.)
7. Report on Panel on Oceanography President's Science Advisory Committee. Effective Use of the Sea. The White House. 1966. pp 144.

THE DOLPHINS ARE IN DANGER BECAUSE OF PURSE SEINING IN THE PACIFIC

by Kathy D. Neill, Aiea High School

In the 15 years that tuna fishermen have been purse seining, hundreds of thousands of dolphins have been slaughtered. Although the National Marine Fisheries Service tried to prevent the killing of dolphins, their efforts toward this end have been fairly unsuccessful. The tuna fishermen do not deliberately kill these dolphins, yet the slaughter continues.

Several factors are responsible. The yellowfin tuna, well liked by fishermen because of its light color and a non-oily taste, associate with the dolphins. Scientists have been pondering the question as to why dolphins and yellowfin associate for years. Some possibilities as to why yellowfin swim with dolphins are that yellowfin may like the protection of the dolphins from sharks. Also tuna tend to group near dolphins because of the dolphin's perfect sense of direction, and they can orient themselves even on the surface.

The first dolphin is known scientifically as *Delphinus delphis*, but has the common names of crisscross, while-belly and common dolphin. "Delphinus is gregarious and sometimes appears in vast herds that churn the water from horizon."[1] The common dolphin is either black or brown in color. The animal's belly is white and has bands of gray, yellow and white on its side.

The second dolphin is *Stenella longirostris* or spinner dolphin. The spinner dolphin got its name from its habit of leaping and spinning in the air. Scientists don't know whether it is a sign of exuberance, amorous demonstration or a distress signal. No other dolphin that is in the wild does this, though bottlenose dolphins can be trained to do it for show.

---

1. Reiger, George; *Audubon* Jan '75, pp 3-27

The Stenella graffmani or spotted dolphin is the last dolphin most commonly seen in the tuna fishermen's nets. Because of the dolphin's spots, its nickname is spotted dolphin.

Another factor responsible for the death of dolphins is purse seining, a technique used by fishermen for 15 years. The fishermen set an enormous net, which is three quarters of a mile long in length and 250 feet deep, around a school of yellowfin and dolphins. Then the fishermen close the net at the bottom with a "purse line". The catch is then hauled near the boat.

After the dolphins are caught in the net, some of them will swim wildly around, then the dolphins group together in one corner of the net making strange noises. Some scientist describe this noise as singing. Many of the dolphins panic and dive underwater, then become tangled in the meshing and drown before they can be released. Other dolphins will go into shock from fright.

Even after the dolphins get moved out of the net, they are still in danger. Hundreds fall prey to the sharks who patrol the net's perimeter. If the dolphins escapes entirely, the animal sometimes will leap compulsively and wierdly across the surface of the water for miles. Their family units are shattered after they are caught and released; the shock effect is still unknown.

In the last 20 years, tuna fishermen have slaughtered hundreds of thousands of dolphins. As many as 600 dolphins are killed per set of the net, some hauls have killed a 1000 animals. Tuna fishermen of all nations may have killed 78,000 dolphins in 1976, over the 66,000 limit. The National Marine Fisheries Service set as a maximum for 1977 at 33,000 dolphins for United States' tuna fishermen.

On October 21, 1972, the United States Congress enacted a law to become effective in December 1972. The law forbids capturing or importing marine mammals into the United States. The law prohibits importing products made from any part of a marine mammals It also authorized a research program to study ways and means of reducing the number of dolphins killed by expeditions. A special permit is needed for very limited importation.

One of the controversial exceptions allowed by the law was a two year waiver for the fishing industry, especially good for tuna fisherman. During that period, fishermen were allowed to continue killing dolphins. This was subject to certain regulations requiring fishing techniques that were least hazardous.

One proposed regulation for the law was that United States canners would not be allowed to buy tuna from foreign sources unless the tuna catch is certified as to have been made under the same laws as the United States fishermen follow.

Jack B. Lindsey, president of a tuna canner company asks, "Who could tell whether tuna caught by one fisherman transfered to a mother ship from another country, and finally sold to a United States processor, were caught according to our regulation?"[2.]

In a ruling by a Washington (D.C.) Federal Court, October 21, 1976, United States fishermen could not kill any more dolphins in 1976, and the Commerce Department set a limit of 30,000 for 1977. On March 8, 1977, the United States Circuit Court of Appeals allowed fishermen to purse sein again and set a limit of 59,050 deaths for 1977, "incidental porpoise kill"[3]

2. Business Week, "The Crisis in Tuna Fishing", November 15, 1976
3. Honolulu Advertiser, "Tuna Netting Permitted, March 8, 1977, D-1

There are ways to prevent dolphins from being killed. One idea was to reduce the fishing nets from a 4 inch mesh to a 1¼ inch mesh. On the top 72 feet of the net, nylon lips or chutes are sewn on. A crew member on a rubber raft would guide trapped dolphins out of the nets. The only danger of this plan is that if sharks are in the net, it can be dangerous for the crew member.

Another method, called "backing down"[4], is where half of the net is hoisted aboard. The tuna is in the front of the net and the dolphins are in the rear. The ship then reverses its engines to cause the far end of the net to sink. The dolphins can escape, but so can the yellowfin. If crew members are near the area where the dolphins escape with cane poles, they can catch all the yellowfin that escape.

Therefore, I feel Congress in this Session should make the maximum limit of killing dolphins zero. In 1972, along with the law, Congress did provide funds to help research for better techniques of tuna catching. In the Hawaiian Islands, tuna fishermen use other methods to catch aku and ahi. Thus use bait fish, especially nehu, but are faced with two problems. The supply of bait fish is limited and it is not as profitable as purse seining. There are research efforts underway in Hawaii to develop an acceptable bait fish for the Hawaiian fishermen, even though such techniques of fishing is not as profitable as netting. The Pacific tuna fleets should follow Hawaii's good example.

The dolphin population may become lower and lower if we do not stop fishermen from killing 66,000 dolphins a year. There are no legitimate reasons, I feel, why such numbers of dolphins are killed. Tuna fishermen should learn ways to avoid such death if utilizing purse seining or be

4. Cousteau, Jacques, Dolphin, p.224

outlawed from doing it.

The United States has asked Japanese and Russian whalers, to stop the slaughter of the whale. The United States should also set a good example by outlawing the killing of dolphins, and take the lead in providing effective alternatives to the needless slaughter of dolphins.

BIBLIOGRAPHY

1. Alpers, Anthony; Dolphins; the Myth and the Mammal, Boston: Houghton Mifflin 1961

2. "Congress Considers Court-Ordered Tuna-Porpoise Fishing Ban", June 13, 1976 Congressional Quarterly Weekly Report, p.1523-5

3. Cousteau, Jacques,Vves, Diolé, Philippe. 1975. Dolphins, Garden City, New York: Doubleday and Company Inc.

4. Douglas, Michael, "Killing Porpoises". July 24, 1976. The New Republic 175"6-7

5. "Fate of the Dolphin". July 1974. Chemistry. 47:24-5

6. Reiger, George. "Dolphin Sacred, Porpoise Profane". January 1975 Audubon p. 3-28

7. Reiger, George. "Four Small Toothed Whales called'Vulnerable' by IWC." September 1976, Audubon. 78:124

8. Sténuit, Robert. The Dolphin, Cousin to Man. 1968. New York: Sterling Pub. Co.

9. "The Crisis in Tuna Fishing". November 15, 1976. Business Week, p.130

10. "Tuna Netting Permitted." March 8, 1977. Honolulu Advertiser.D-1

OUR NEW 200 MILE LIMIT
by Lee E. Tasaki, Kailua High School

On February 22, 1977 the new 200 mile limit was sit. The reason was so that we could control fishing in these areas. This new zone includes the countries of America, Canada, Britain, Mexico, Chile, Norway, Brazil, the Soviet Union and dozens more. We the United States are trying to end the ruthless competition which is threatening to turn our ocean into an aquatic wasteland. Sometime this year the European Common Market is expected to adopt similar limits.

This does present a problem on being able to watch 2.5 million square miles of open ocean. Inside this zone, the United States Reserves will have the right to decide who fishes where, how, and of what species. Foreign fighermen will be able to fish in our waters, but they will have to purchase licenses and follow very strict American rules.

Since the early 1960's, large trawlers from Japan, Russia, Poland, East Germany, South Korea, Spain and other nations have come to our coast lines to fish. The East Coast is probably hit the hardest, they figure somewhere from 800 to 900 fishing vessels come there each year.

Some of their big vessels are larger than football fields and carry a crew of 100 men. They locate first electronically and then move like sweepers, clearing everythin in the nets path.

A single set of nets may take more fish than an average American vessel does in a year. Most of the American fisherman today still fish with hooks, trap or hand line from small boats and with a crew of three to four men. Landings of Pacific Ocean perch on the Oregon coast average about 15 million pounds per year. Three years later when the Japanese and Soviet trawlers came around the American landings were down to 1 million pounds.

In 1961, New Englanders took 742 million pounds of good fish from the Georges Bands of Cape Cod. Ten years later another 380 million pounds. It is said that Atlantic haddock and halibut stocks have gone down 10 percent of their former yields.

From 1970-1974 the Japanese catch grew 15 percent, Soviet Union 27 percent, and South Korea 145 percent. Americans, who a decade ago imported one quarter of their commercial fish are now importing more than three quarters of their needs.

This is not only an American problem. As nations have depleted the ocean's resources, hostile encounters have been brought on. Last year, the British fought a six-month 'cod war' with Iceland. Norwegions have fired upon Soviet ships,in Java fistfights and boat burnings have broken out between traditional, sail-powered fishermen and owners of motorized vessels.

The trouble is, fish are in short supply. The world catch is about 70 million metric tons. Experts say that the ocean can sustain a yeild of no more than 61 million metric tons.

Inside the United State's 200 mile fisheries conservation zone, the fish are ours. This enables us to maintain a rate of how many fish are and can be taken each year. This new law does invite outsiders to continue to fish these waters but it will never be the same. Regional councils will decide when open and closed fishing seasons will be what fishing grounds should be closed to fishermen and what kind of gear they may use.

This of couse will reduce quotas on all foreign fishermen. There will be some fish that will not be open for foreign vessels like herring, halibut, salmon and crab. This also may bring back some of our old, forgotten fisheries into business.

AQUACULTURE

INHERENT PROBLEMS OF MARICULTURE

by Marc M. Nishimoto, Lahainaluna High School

ABSTRACT

"If there are many types of operations to correct a defect, then none of the operations have proven to be effective."

This maxim has poven to be true in such operations as the arms talks, the criminal justice, system, etc.. And in the attempt to meet world hunger, it is also, unfortunately, true.

However, with the rising of the new culture industry, mariculture, the possibility of ending hunger world-wide has an extremely positive outlook. And not only solving one problem but also producing benefits and advantages such as tax revenues, employment, etc..

Unfortunately, this program is not as flawless as it might seem. There has been some problems within present systems of mariculture, both biological and monetary. In my paper, I will try to point out the significance of these problems which have caused a setback to major operations of mariculture.

"Anything our contemporaries can do on the surface, the mermen of tomorrow will do under the sea." This quote by Jacques Cousteau exemplifies the fundamental philosophy of mariculturists that the industries of the future will be oceanic rather than land-based.

But before the development of such large-scale operations of mariculture can be regarded as feasible, inherent problems must be alleviated.

In current mariculture programs, problems of funding and food supply have stifled large-scale operations of culturing. Two such programs, green turtle and pink shrimp farming, have encountered such proplems. If these problems can be solved with reasonable amounts of time, money, and devotion by mariculturists, the gains of this new industry would be more than rewarding.

Hawaii, the only oceanic state, could become the mariculture capital of the world and could reap the gains stemming from this new industry. However, there are problems that need to be dealt with before this industry can be established. This paper will discuss two inherent problems in mariculture and examples of each. In the case of green turtle farming, the problem has been a biological one. Let"s investigate the present system and the problem it faces.

The prominence of green turtle farming first occurred in mid-1972 in the Cayman Islands. In that year, Mariculture Limited, which founded the farms, introduced its products into the Cayman markets. Every part of the turtle is used as a product. The turtle was processed into a variety of products including calipee, steaks, calipash, belly shell, flippers for the soup trade, fat for the cosmetic trade, liver for sausage, offal for cattle feed, polished shells, scutes, and leathr items for the tourist trade.[1] The eagerness with whibh the products were purchased thereafter established a good business for Dr. Robert Schroeder

[1]Reiger, George, 'Green Turtle Farming; A Growing Debate', Sea Frontiers, 21(4): 222, July-August 1975.

and his wife, who together founded the turtle farm. Since then, other turtle farms have been established through financing from Mariculture Ltd., with beneficial results. However, the turtle farms have not beem withput problems.

Many experimentations on the formula for turtle food were conducted. The first formula was a feed also used for catfish. After a period of two years, this formula was discarded for a more specialized formula, which is mostly comprised of fish feed. The formula for this feed was obtained from an amino-acid analysis of different animals. At the present time, they are fed a varied diet, with a special soybean derivative pellet, which is placed directly to the holding pens of the turtles.

But again, problems arose from the formula and thefeeding. The unconsumed feed, which was flushed into the sea outside of the farm complex, has caused a biological unbalance. The unbalance has caused an overabundance in algae growth which, although is more suited for fishlife, had a detrimental effect on the coral life.

As in any new operations undertaken, problems will arise. Fortunately, the problems that are faced in the turtle farms are rather easily remedied. One way to alleviate the problem of the unconsumed pellets is to introdece a bottom feeder into the turtle tanks to consume the untouched pelltes. By introducing a bottom feeder, the problem of the effluent would probably be remedied, and also' the bottom feeder might be, in turn, used as a possible culture specie. But, then again, this is a hyputhetical situation and not one which has been proven to work. However, there is a way that has been proven, or rather inferred, to work. This solution, under whihh is currently used in an algae/oyster farm, has promising effects. The method has as its primary components seawater and raw sewage. Let us investigate the mechanics of this method.

At Woods HolesOceanographic Institution, the first algae/oyster farm, it has been proven that sewage can be diluted and reuse in different ways, including an environment in which algae can grow. Presently, algae is being grown in sewage which will be used later as a feed for the oysters. In stimulating growth of algae, mariculturists are able to produce two advantages; first, the pollutants in the sewage are consumed, and secondly, the algae is used as feed for other mariculture species. Let us investigate the first advantage.

Obtaining raw sewage is no problem, but the treatment of it is a rather difficult task. First, the sewage has to go through two treatments to reduce the quantity of the toxic materials in the sewage and let remain only inorganic pollutants, such as phosphate and nitrogen compounds. Then, seawater is added to the effluent which remains to stimulate growth of algae. After the algae starts to develop, it begins to reduce the inorganic materials. The result is cleansed water and algae, which is the primary food for the oyster culture at Woods Hole.

Therefore, it has been shown that mariculturists benefit from the treatment of sewage in that it is a new source of food for the 'farms'. In retrospect, it has been shown that algae will grow in sea water and diluted sewage. But what would happen if the diluted sewage was to be mixed with the nutrient-rich effluent stemming from the turtle farms? I think it is obvious that this process, if it is put into effect, will alleviate two problems; the reduction of sewage and the elimination of the nutrient-rich effluent of the turtle farms.

In the second advantage of growing algae in sewage, the benefit is a direct result of the first advantage. The effluent that is used for the feed of oysters is also the primary feed for a number of other maricultured species. One such specie which lives on algae is the pink shrimp, "Penaeus duorarum". The algae would prove to be an ample food supply for the shrimp. This path will be investigated later. First experimentations with pink shrimp farming were conducted in 1963 when a University of Miami student successfully raised a few pink shrimps from egg through the first ten stages of life, which are considered the most delicate and difficult periods for raising shrimps. Since those first experiments, the progression of shrimp farming has accelerated and it has introduced a new way to supply the demand of a well known product.

The potential gain from a large-scale shrimp farm is enormous. In 1972, the U.S. had to import approximately 575.6 million kilograms of head-off shrimps to sustain the demand for shrimp, even though the U.S. harvests that year were approximately 549 million kilograms of shrimp. The importation of foreign goods shows that the present domestic harvests cannot meet the demand of the public. Clearly, a large-scale shrimp farm operation would make the potential monetary gains overshadow the difficulties of the mechanics involved. But again, just as the turtle farms, problems arose with shrimp farming. The major problems were financial expenses. The two main items which contributed to this problem were the difficulty of obtaining viable shrimp eggs and the cost of food for the shrimp.

Mariculturists at the Turkey Point Shrimp farm had to call commercial fishermen to see whether they had caught any gravid, or egg-bearing, shrimp. If they had, chartered boats from the farm would have to go out and collect these shrimps. However, these chartered boats cost from $200 to $400 a night, and it takes several nights to harvest the shrimp. Accumulation of such costs could prove to be a disastrous setback if the farm doesn't live up to its expectations.

Another item which contributes to thefinancial woes is that the cost of feed for the larvae stages is increasing. The primary formula used to feed the larvae costs about $4 per kilogram. The cost of the least expebsive feed doubled between the years of 1969 to 1974.

Problems such as these have stifled a large-scale culture operation. If such an operation, a highly inclusive one, was to be put into effect, the demands of the consumer would probably be met.

Discussed so far has been the problems which exists, or have existed, within two present systems of mariculture. The problems which have been solved have contributed to the progress of mariculture. Those problems which have not yet been solved could prove to be a barrier of great significance to the future of mariculture, particularly here in Hawaii.

Takuji Fujimura, developer and chairman of the State's Anuenue Fisheries Station, stated, "the biggest problem in moving faster in aquaculture simply is money'.[2] Here in Hawaii, a comprehensive mariculture progeam could become one of the state's major and most beneficial industries. But because it is located in the middle of the Pacific Ocean, Hawaii faces different problems than those existing in current programs. But these new peoblems could be easily remedied through state and federal funding and support. Although Hawaii has received one of the largest grants from Sea Grant, the federal funding has leveled off during the past three years. This causes a real problem because of the lack of growth potential, and the cost-of-livang must be absorbed.[3]

Hawaii could become the mariculture capital of the world because it has all of the natural resources needed to start a large-scale program. However, as previously stated, there are two major problems within present systems of maricultute that have stifled initial work in America and here in Hawaii.

There are initial initial indications that these dual problems of obtaining suitable food and properly disposing of waate materials coild be solved by using waste to stimulate the growth of algae. We need to develop programs to test these processes. Funds are needed to begin such programs, yet allocations of federal funds cannot meet the need of starting a mariculture program in Hawaii. Commercial

---

[2] Altonn, Helen, 'Big Hopes, Limited Funds', Honolulu Star-Bulletin, February 22, 1977, Progress Section 1-Land, p.16

[3] Altonn, Helen, 'Isle Aquculture Potential ?Seen', HonolulumAdvertiser, June10, 1976, H-1

concerns seems to be unwilling or unable to develop a large-scale solution to the problem.

Clearly, this infant industry is having problems growing up. However, if this infant doesn't develop, the world will lose an individual that could contribute to the solutions of its problems.

BIBLIOGRAPHY

1. Altonn, Helen, "Isle Aquaculture Potential Seen", Honolulu Star-Bulletin, June 10, 1976, H-1.
2. Altonn, Helen, "Big Hopes, Limited Funds", Honolulu Star-Bulletin, February 22, 1977, Progress Section 1- Land.
3. Norris, James D., "Shrimp Farming", Sea Frontiers, March-April, 1974.
4. Palmer. H.V.R., "Recycling Wastes for Mariculture", Sea Frontiers, November-December, 1973.
5. Reiger, George, "Green Turtle Farming: A Growing Debate", Sea Frontiers, July-August, 1975.
6. Sefton, Nancy, "Now They're Farming Turtles", Oceans, September-October, 1974.

TILAPIA: POTENTIAL AQUACULTURE CROP FOR HAWAII

by Tina L. Daehler and Laura L. King, Kapaa High School

ABSTRACT

In this paper we will explore the characteristics of the Java tilapia (Tilapia mossambica). It is a universal source of food for man, and many growing "wild" in our reservoirs and elsewhere should be considered for another aquaculture crop for Hawaii. We will also discuss how tilapia have been cultured in various countries, and the possibility of polyculturing it with eel (Anguilla japonica).

INTRODUCTION

Since recorded history began, tilapia have been an important source of food for man. As far back as 2,500 B.C., tilapia were harvested and may have been cultured, according to an Egyptian tomb frieze. In the Bible,the fish that Christ fed the multitudes were, in fact, tilapia. Up to the present, tilapia have been an important source of protein in Southeast Asia, the Near East, and in Africa.

In Hawaii, as well as the rest of the United States, this fish is looked down upon as "that ugly fish in the muddy water". This "ugly fish in the muddy water" deserves more of a chance to prove itself.

According to Kauai's Marine Advisor, tilapia are an important food resource. It has more protein than beef, pork, or lamb with less fat. Tilapia contain an abundace of vitamin A, B complex, and minerals. Tilapia would be an excellent fish for culturing because of its hardiness, ease of breeding, rapid growth, and high quality flesh. In addition to this, tilapia adapt easily to various water conditions, and they accept many types of diets.

Tilapia's qualities enable it to occupy almost any setting, including our markets, if only we would let them. The question now stands as: Is it a worthwhile effort to develop this type of aquaculture in Hawaii?

TILAPIA IN HAWAII

Twenty-four years ago, Java tilapia (Tilapia mossambica) were brought to Hawaii by the Territorial Division of Fish and Game. The tilapia were to be used in clearing the aquatic vegetation in canals, for food as game fish, and possibly for tuna bait. Today all the "wild" tilapia found in reservoirs and elsewhere can be traced back to these fifteen imported survivors. By investigating the "tried" methods of spawning, growth rate, solutions of overpopulation, harvesting, and marketing, it is obvious that Hawaii is a practical kingdom for tilapia.

SPAWNING

Spawning in tilapia, not like most other fish cultures, is very easy and presents no problem. This allows tilapia farmers to farm without learning extensive skills or technological know-how.

Tilapia are mouth-breeders. The male scoops out a small hole on the pond floor with his mouth. A receptive female lays seventy-five to two-hundred eggs there. After fertilization by the male, the female incubates the eggs in her mouth for three weeks. The eggs hatch at three to five days. The fry can remain in the mouth of the parents for safety. This results in a high survival rate.

The ideal setting for spawning would be in a pond of 1000 m^2. Tilapia spawn in warm water, on a loose, sandy bottom. The pond should contain twenty-five to thirty females and half as many males.

Tilapia breed every three to six weeks in warm water. In Hawaii spawning would continue throughout the whole year, since there is no abrupt decrease in temperature. (In cooler parts of the world, tilapia have a nonreproductive period of about two months.)

Tilapia prosper anywhere from fresh water to sea water. Java tilapia are able to survive and spawn in water of 3.5% salinity. (Average salinity for sea water is 3.5%.)

Spawning frequently is one of the factors which determine the growth of tilapia.

GROWTH OF THE YOUNG

Like spawning, stocking methods and food supply also determine the growth of tilapia.

Stocking Systems

There are two types of stocking systems: Monoculture and polyculture.

Monoculture is the less popular of the two and is practiced, on a small scale, in rice fields in Southeast Asia. These stocking rates were 120 to 180 fingerlings/ha.

The "normal" figure for tilapia production in a monoculture pond is 500 kg/ha in the tropics and decreases with colder climates. However, the production can yield 1000 to 2500 kg/ha with fertilization and/or supplementary feeding. In subsistence culture, a smaller production output is more beneficial to the culturist because there is less competition for food and space, i.e., tilapia can be farmed uo to 18,000 kg/ha, but there would be an overabundance of fish too small to be of importance.

Polyculture of tilapia can be split up into two basic parts:

a) increasing production of each fish used

b) increasing production of tilapia only

An example of increasing the production of each fish in use, is a commercial pond polyculture in Uganda. There, *Tilapia mossambica* and common carp yielded total production higher than can be achieved by monoculturing either fish.

At Auburn University, Alabama, experimental cultures with *Tilapia nilotica* (2500/ha) and channel catfish (7500/ha) yielded a better total production than could if each were monocultured.

H.W. Swingle from that University, suggested that this takes place on account of the channel catfish (*Italarus punctatus*) conceivably acting as a predator on the tilapia fry. Although considerable consumption of tilapia fry by catfish was not observed, the tilapia made use of not only plankton, but wastes and excess feeds meant for the catfish. Also, production of catfish was extensively increased.

In Camaroon, the other type of polyculture was carried out. *Tilapia nilotica* and *Heterotis niloticas* and *Hemichromis fasciatus* were farmed in both subsistence and commercial pond cultures. The results were good production and effective population control of tilapia.

Another took place in India. Tilapia was cultured with milkfish and catla in very fertile ponds. Although the milkfish and catla were practically wiped out, the tilapia production was good.

Food Supply

Food supply, the other factor in growth, is no problem for tilapia. Tilapia accept many types of diets. They benefit from algae, plankton, insects, table scraps, flour, rotten fruit, coffee pulp, and in some cases, will accept animal feed. An illustration of how adaptable tilapia are to different types of food is in the Congo. Mill sweepings were thrown into tilapia ponds. This resulted in production much above the normal for that area.

In a study at Auburn University with Java tilapia, it was found that they grow best when fed food amounting to 3% their body weight per day.

Pond fertilization is very important in a plankton-feeding species. As with supplementary feeding, much more research has to be done in this area. Again, at Auburn University, studies were carried out with Java tilapia, involving the use of phosphates (which is the best group of fertilizers for inciting phytoplankto production). A series of experiments using 8-8-2 (N-P-K) fertilization, 0-8-2 (N-P-K) fertilization, or no fertilization at all, showed that fertilizers definitely increased tilapia production. It was also discovered that the 0-8-2 (N-P-K) mixture was more effective than the mixture containing nitrogen compounds.

In Southeast Asia, sewage is used for fertilization of tilapia. Also, the chemistry of the water and soil must be taken into account before fertilization. But again more research must be made.

POPULATION CONTROL

The biggest problem in tilapia culturing is that of overpopulation which can cause stunting. It has been found that environmental factors dominate genetic factors in size determination.

There are three ways to overcome this problem:

a) separation of parents and young

b) monosex culture

c) control by predators

Separation of Parents and Young

There are two ways to separate parents from their young. One is to net out the adults after spawning, leaving the fry behind. The captured adults are put in another pond to spawn again. But this practice is not feasible because the breeding cucles of each adult don't happen simutaneously.

The more practical way of separating the young has been accomplished in Indonesia. A drainable spawning pond is set above the fry pond. After the eggs hatch, the adults are disturbed so they'll release the larvae. Then the larvae are drained into the fry pond. (The fry mature at 2-3 months and can then spawn.)

Monosex Culture

A more commonly used method is the monosex culture. By individually sorting out stock, the sexes are separated. This is a hectic way of overcoming the overpopulation problem. One female mistakenly let into a pond of males can ruin all the effort involved. So, another method of monosex culture is hybridization. Attempts at crossing various species of tilapia have proven successful. Three groups of crossbreedings have produced 100% male offspring. But males have one disadvantage: they continually dig spawning nests which can eventually ruin the bank of the pond.

A lot of technical management is needed with government concern, rather than small farmers lacking time and the technological know-how needed.

Control by Predators

The last method of overpopulation control is that of adding predators to the tilapia ponds. The predators eat the excess tilapia, decreasing the stunting rate of the tilapia. This is carried out in Africa and Southeast Asia with catfish of the genus Clarias. Also eels (Anguilla japonica), largemouth bass (Micropterus salmoides), ans carnivorous sichilds such as Serranochormis robustus and Hemichromis spp. are used.

As of March 10, 1977, a propsal has been passed through the State House to experiment with eels in aquaculture, since there is a big demand for eels in Japanese and European markets. One of the arguments against the bill was by Domocrat Jack Larsen, D-8th Dist., "Once let loose in our fresh water streams they will compete directly with prawns and other animals that need our limited freshwater source."[1] Democrat Kawakami replied that as far as he knows "it is virtually impossible for the eels to spawn in fresh water."[2] Whether in fresh or brackish water eels would act as one of the predators for controlling overpopulation of tilapia. At the same time it would be a polyculture producing both eel and tilapia for human consumption. With this predator control there would be less stunting and more growth. In fact under very favorable conditions a single Java tilapia csn reach a weight of 850 grams in one year. It may be noted also that males grow two to three

---

[1] Gregg K. Kakesako, "Eel Bill Squirms Past House", Honolulu Star-Bulletin (March 11, 1977), p. A-16.
[2] Ibid., p. A-16.

times faster than females.

HARVESTING AND MARKETING

When the desired weight is reached harvesting is performed, either by seining or pond draining. If part of the crop is to be left back, electrofishing is best because it doesn't cause damage to them.

After harvesting tilapia can can be sold fresh, iced, or frozen. Tilapia too small for marketing can be used as bait, livestock feed, or feed for other fish cultures, such as trout or eels.

CONCLUSION

Because of the excellent qualities of the tilapia, we feel that Hawaii should take advantage of them and develop tilapia into a major market product.

In researching this topic, we have found that there are only two real problems in farming tilapia in Hawaii.

Due to the tilapia's efficiency in spawning, the pond can become overcrowded, causing stunted fish. Other countries have farmed tilapia and eel together and have overcome this problem. Since there is a proposal to experiment with eel as an aquaculture crop, and there is a big demand for eel in Japan and Europe, why not farm tilapia and eel as a polyculture?

The other problem is its reputation. Although tilapia is a gourmet food in places like Pakistan and parts of Thailand, people in Hawaii are not that eager to try it. Tilapia actually has a high quality flesh, plus an abundance of protein.

The tilapia found in Hawaii is the Java tilapia (<u>Tilapia</u>

mossambica), and is the most adaptable and most commonly consumed species in the world.

What are we waiting for?

BIBLIOGRAPHY

BOOKS

Bardarch, John E., McLarney, William O., and Ryther, John H., Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms, New York, Wiley Interscience, 1972, pp. 350-384.

Wolfe, Louis, Aquaculture: Farming in Water, New York, Putman, 1972.

PAMPHLETS and ARTICLES

Altonn, Helen, "Fish Farming: Big Hopes, Limited Funds," Honolulu Star-Bulletin, Feb. 22, 1977, p. 16.

__________, "Isle Aquaculture Potential Seen," Honolulu Star-Bulletin, June 10, 1976.

Kakesako, Gregg K., "Eel Bill Squirms Past House," Honolulu Star-Bulletin, March 11,1977, p. A-16.

Marine Advisory Program, Conservation Information, "Tilapia, A Fishy Tale,".

__________, "Tilapia".

__________, "Agronomics View Aquaculture in North Africa".

Markrich, Mark, "Aquaculture Boom," Honolulu Star-Bulletin, Feb. 22,1977, p. 16.

Walsh, William, "Hard Look at Aquaculture," Honolulu Star-Bulletin, Feb. 2, 1977.

AQUACULTURE IN HAWAII: METHODS AND PROBLEMS

by Carol S. Okimoto, University Laboratory High School

ABSTRACT

Aquaculture can play a major role in supporting Hawaii's economy. It will generate more jobs and use less land than sugar cultivation and will potentially yield more money per acre. Five major management systems for aquaculture in Hawaii are compared with static pond culture emerging as the most promising. Suitable environmental characteristics for aquaculture are considered. Water pollution and diseases are discussed as potential threats. Ongoing scientific research in aquaculture is shown to be indispensable and the compatability of aquaculture with other shoreline activities is considered.

INTRODUCTION

In this paper I will dèscuss the feasability of large-scale aquaculture as an important economic activity for Hawaii. I will look at management systems, environmental needs, hazards in production and competition for use of the shoreline and land.

METHODOLOGY

The research for this paper included a personal interview, examination of important reports, articles and books. The discussion which follows analysès important issues and raises important questions about aquaculture for Hawaii.

AQUACULTURE IN HAWAII: METHODS AND PROBLEMS

Historical records show that the Japanese and Chinese cultured fish as far back as 4,000 years ago. In ancient times traveleds who went to the Far East returned, and taught the Romans how to raise carp. Recently archeologists in Greece dug up a book on the culture of carp written in 460 B.C. Wealthy class of people had ponds long ago and used them for both growing and storing fish. Records dating back 600 years show that the government of Java passed laws setting up severe penalties for anyone caught stealing fish from ponds. And as far back as 500 years ago carp culture was common throughout Europe.[1]

For more than 800 years, Hawaii has had some form of fish-farming. An art practised by ancient Hawaiians in more than 350 ponds throughout the islands.[2] Today only 141 ponds can definately located. The remains of these old ponds structures revealed that the ancient Hawaiian people achieved some degree of sophistication. They built stonewalls around mouths of natural inlets, and diverted streams to trap the fish, it guaranteeing a constant supply of food.

Modern aquaculture in Hawaii is less than 15 years old. At the present moment, 16 aquaculture farms exist throughout the islands. About 20 ancient Hawaiian fishponds are currently being used, 18 for home use and 2 for commercial purposes.[3]

Before considering major production, there are benefit and limitation factors to consider. The establishment of an aquaculture in Hawaii will play a major role in supporting the State economy. It will increase sources of tax revenues to the State such as real property taxes from more productive valuable land, general excise taxes from sales of products and income taxes from workers and owners. These vital sources will be essential to broaden our tax base and put less pressure and demand on agriculture, tourism and military. It will create new jobs for Hawaii's skilled and semi-skilled people, thus reducing unemployment. This industry will generate about one job and one and a half indirect jobs per ten acres of pondland while our present papaya industry employs only one worker per 25 acres. Sugarcane currently employs one worker per 22 acres in production. For instance, one acre of prawns can yield $10,000 income per year while one acre of sugarcane yields only $1,500 income per year. If $4,000,000,000 income per year of sugar were to be made, 240,000 acres would be used while on the same bases using prawns, only 24,000 acres of land will be used.[4] It will also fulfill the State's desire for a greater independance from mainland and foreign imports, particularly food products. "Approximately 80 percent of all goods and services purchased in Hawaii are shipped into the State."[5] Aquaculture will also provide worldwide export to developing countries where aquatic food products would act as a low-cost food protein. Price fluctuation due to variable supply and demand however may limit aquaculture production. Variable demand for the fish produced is equally important. The method of production may also affect consumer acceptance.[6]

Most aquaculture production in the world makes use of one of five management systems depending on the physical geographical features of the area, location, and the intensity of culture.

These five systems are briefly described here:

Ranch Culture In this system animals under culture browse or forage for natural food in large natural water embayments or sheltered coves. A good example is salmon culture. The young salmon feed, grow and mature in the ocean. Then they migrate back up their "parent stream" to spawn. They are then removed for spawning stock. Hawaii has virtually no area where this system of management could be applied.[7]

Static Pond Culture In this system stock are confined to man-made earthen or concrete ponds. The size of the pond vary from 1-2,500 acres. The most widely used size production ponds rances from 40-150 acres depending on the intensity of farming. Small ponds present fewer problems in managing, harvesting and treating disease and parasites. Because the water area is greater in a large pond, the wind is able to make waves resulting in fewer oxygen problems. This advantage in turn is off set by the serious problem of dam or levee erosion. This basic system with its various modifications is probably the system most prevailent in the world today. Hawaii has numerous examples of this type of farming technique and is likely that more operations will come about in the immediate future.

Raceway Culture In this system high stock densities in an area is permitted because of a large volume of water flowing naturally or is pumped continuously and is passed through the enclosure.

Two kinds of raceways are used based on how the water is circulated. Raceways in which water enters at one end and is disposed of at the end is known as the "open" raceway. The water is not used again. Hawaii has one commercial operation in the development stage. In general, this type of aquaculture seems applicable to Hawaii because land cost for large operations are high and water in certain areas is plentiful. Raceways in which the water enters at one end and is removed at the other end, filtered of its wastes, aerated and used again are "closed" raceways. Raceways are only feasible if large quantities of cheap high quality water is available for the "open" system or if the water can be removed and waste effectively removed for a "closed" system. The present level of technology is inadequate to produce a healthy crop at a commercially profitable level. Labor requirments for the recirculating system are high and costly due to the need for continuing maintenance and observation.

Cage and Basket Culture In this system the stock is confined in wire mesh or net cages suspended or supported (on rafts) in large bodies of water. Predatation can be controlled but products are easily stolen by poachers. This technology is applicable to certain ponds and embayments in Hawaii where pollution and problems do not exist or can be controlled.

Closed Density Culture In this system the stock is confined in a "container" through which a continuously recycled flow of water is passed. This highly sophisticated type of management is environmentally controlled (oxygen and temperature is constant all year around using modern techniques). This high density culture requires very skilled and knowledgeable management. This technology seems applicable to Hawaii in view of small land requirement of the system.

Suitable environmental characteristics are essential for a healthy production and profitable farming. Available resources should be abundant if the aquaculture industry is to prosper to its maximum. Hawaii's most available physical resources is its warm temperature clean ocean water. However, Hawaii's most valuable resource because of its limited availability-- is land. This situation prevails largely for several reasons. One of them is the land ownership pattern in Hawaii. Ownership of land is highly concentrated. The State, County and Federal governments together control about 48 percent of the total land area. About four-fifths of there public lands constitutes the bulk of forest reserves. About 25 percent of these lands are under leases, principally for agriculture purposes. Private ownership of land (52 percent of the total area) are also highly concentrated. Ninety percent of this private land belongs to fewer than 40 owners, each with 5,000 acres or more. Agriculture is the primary user of land in Hawaii. Almost three-fourths of the total land area is used for forestry and grazing and for plantation, and to a small extent, diversified crops.[8]

Palis and barren lands, that is lands incapable of use incapable of use because of steepness or lack of productive capacity, occupy about 12 percent of the total area.[9]

Water for aquafarming can be obtained from several sources. City water , surface run-off, wells, springs and industrial thermal wastes. Under proper conditions, each may be suitable for use. Rainfall which does not soak into the earth is know as run-off. Surface run-off may include water taken by streams, reservoirs as well as surplus rainfall from around the immediate area which may rundirectly into the pond. Run-off may be an economic source of water for culture. One of the most serious problems in using the run-off is that it may pick up harmful residues and aquatic pests. Run-off from nearby farmlands may carry pesticide residues and poison harmful to the fish.

Some industrial plants may release waste water which are most of the time safe for culture use. Such waters has usually been warmed several degrees thus influences the rate of metabolism and resulting in rapid growth of the animal. The main problems with water management are related to oxygen depletion and water pollution. Oxygen depletion may cause death of all the fishes in a pond in a matter of hours. Fishes that do not die of oxygen depletion will eventually die of bacterial infections or diseases which become more susceptable under stress. Oxygen problems are also indirectly related to weather conditions.

Cloudy weather with very little wind may cause the supply of oxygen in the water to become low.

The most common source of water pollution comes from city sewage. The pollutants not only stunt the growth but kills the numerous forms of life that lives in the water. They absorb oxygen from the water, killing the fishes by suffocation. Other pollution substances destroy plant life and without it, all life must come to an end. Mercury can be extremely harmful. Contained in industrial wastes, it is absorbed by the fish. When these contaminated fish are consumed by humans in great quantities, it may cause severe illness. Another form of industrial pollution is thermal pollution. Electrical power plants use billions of gallons of water to cool their turbines. The water becomes heated and when it flows back into the streams, it raises the temperature. It kills many fish which cannot adjust to the sudden increase in temperature. Another form of water pollution comes from pesticides and insecticides. These are used by dirt farmers to kill weeds, rodents, insects and lice. These chemicals find their way into the waters, contaminating them. They may be blown there by the winds or carried by run-offs from farmland into streams or directly into nearby culture ponds.

In open aquaculture systems which use natural later, there is a constant danger of aquatic predatatons. An example of this situation in Hawaii is the problem of saltwater fishpond operators have with barracuda.

"Trash" fish can also be a nuisance. They compete with the fishes for oxygen, space and feed.

Fish much as other animals are susceptable to certain diseases and parasites. In culture, the high population density tends to magnify some of the problems such as the incidence and spread of disease and parasites. Such outbreaks may be the result of inappropriate management procedures, which in turn causes environmental stress on the stock. which in turn makes the animals susceptible to contact disease.

Mariculture in Hawaii would be a little more complicated because of the uncontrolled environment, Such operations would conflict with the recreation users and the esthetics of the ocean front. Recreational use in heavy in Hawaii and primarily oriented toward boating, sport fishing and surfing. Hawaii in comparison to Japan's embayments are quite the opposite. Recreational boating, sporting fishing and, surfing are almost non-existent in Japan and marine aquaculture has been a major production for a long time. If we were to expand our use of marine coastal areas for aquaculture to the extent that Japan has, it will create a serious conflict with the recreational users. I would think that only a national food crisis could force us into that position.

Here in Hawaii people place an extremely high value on our coastal zones. People who own shoreline property regard their unobstructed view as assets and can become powerful force if their view is obstructed. Commercial floating farms (cage and bas basket culture) is a type of management that will conflict with shoreline residents.[10]

Large-scale aquaculture should be encouraged in Hawaii. The problems with aquaculture today may seem infinite but are no greater than those faced by farmers with agriculture.

Scientific research projects in Hawaii are investigating techniques in spawning, rearing, food requirements, and many other factors related to culture of aquatic animals. Research will bring out the "best" results for mass production and minimize the problems.

FOOTNOTES

1. Louis Wolfe, Aquaculture: Farming in Water, (New York, G.P. Putnam's Sons, 1972), p. 13.

2. Helen Altonn, "Fish Farming: Big Hopes, Limited Funds," Honolulu Star-Bulletin, (February 22, 1977) p. 16.

3. Richard Gibson, interviewed by Carol Okimoto, (University of Hawaii Aquaculture Department, Honolulu, Hawaii), 3:30 P.M. February 7, 1977.

4. Ibid., interview.

5. Department of Planning and Economic Development, State of Hawaii Growth Policies Plan: 1974-1984 quoted by John S. Corbin in Aquaculture in Hawaii 1976 (Department of Planning and Economic Development in State of Hawaii January, 1976)

6. Ibid., p. 30.

7. Ibid., p. 27.

8. University of Hawaii, Atlas of Hawaii, quoted by John S. Corbin in Aquaculture in Hawaii 1976 (Department of Planning and Economic Development, in State of Hawaii January, 1976), p. 24.

9. State Department of Planning and Economic Development, Hawaii: The Natural Environmental quoted By John S. Corbin in Aquaculture in Hawaii 1976 (Department of Planning and Economic Development, in State of Hawaii January, 1976), p. 24.

10. Anthony J. Novotny, "Tough Growing-Up is Seen for Aquaculture," National Fisherman 1976 p. 128.

BIBLIOGRAPHY

Altonn, Helen, "Fish Farming: Big Hopes, Limited Funds," Honolulu Star-Bulletin, February 22, 1977, A-15.

Bennett, George William, Management of Lakes and Ponds, New York, Van Nostrand ReinHold Co., 1971.

Corbin, John S., Aquaculture in Hawaii 1976, Department of Planning and Economic Development, Hawaii, January 1976.

Department of Planning and Economic Development, Hawaii Aquaculture Planning Program, Hawaii, 1977.

Gibson, Richard, interviewed by Carol Okimoto, University of Hawaii Aquaculture Department, Honolulu, Hawaii, 3:30 P.M. February 7, 1977.

Lee, Jasper S., Commercial Catfish Farming, Illinois, The Interstate Printers and Publishers, Inc., 1973.

Mack, Jerry, Catfish Farming Handbook, Texas, Educator Books, Inc., 1971.

Neil, Richard D., "Aquaculture Could Benefit State" Honolulu Star-Bulletin, February 9, 1977.

Novotny, Anthony J., "Tough Growing-Up is Seen for Aquaculture," National Fisherman 1976.

Wolfe, Louis, Aquaculture: Farming in Water, New York G.P. Putnam's Sons, 1972.

AQUACULTURE 50
by Lisa A. DeLong, Kalaheo High School

As the earth's population increases, available farm land decreases. With more and more people looking towards the sea for an occupation, the ocean's resources will soon become drained. Seafood is rapidly growing in popularity. Housewives no longer carry the dread of scaling and cleaning fish. They buy it frozen, packed, and prepared for cooking. Refrigerated trucks and railroad freight cars can transport sea products thousands of miles inland. Doctors recommend fish for every diet. They are rich in minerals, vitamins, and proteins, and contain ingredients that fight bacteria and viruses. With their haphazard fishing techniques, fishermen have no way of knowing whether the daily catch will meet its quota. Fishermen also face problems involving government restrictions and pollution. As a solution to the food shortage on both land and in the ocean, consider aquaculture: the cultivation of both plant and animal life in water from its earliest stages until full grown, harvested and sold in the market.

Sea Farmers are faced with many problems in their search for the least expensive yet most qualitative product. Real estate developers reclaim much land from the seacoast and build factories, houses and recreation fields. In doing so they eliminate marshlands and estuaries which could become rich nursery grounds for many species of plants and animals. Other problems that confront the sea farmer include weather conditions, preditors like sharks, loss of feed to other fish, and lack of control of waste. Always in offshore waters is the question of ownership of crop. three main illnesses affect fish: parasites, natural and man made pollutants, and improper feeding. A good farmer keeps his water clean by changing it at frequent intervals and never overfeeding.

Parasites flourish in filthy water. Older fish are often often removed because of their susceptibility to disease.

Scientific research in genetics has enabled sea farmers to breed larger, faster growing, more meat producing and disease resistant plants and animals. By studying mating, spawning and hatching of eggs scientists have succeeded in breeding fish with desirable characteristics. As this type of research continues aquaculture will become less of a gamble as an occupation.

The State Agricultural Department has approved of four loans for aquaculture enterprises under a loan program established in 1971 by the legislature. Reports on their farms follow. Taylor Pryor expects much success from his Kahuku Seafood Plantation. As a farmer grows hay for cattle, Pryor produces plankton for shellfish. His oysters can be harvested at seven months, where as a calf takes two years. This sea farmer claims that he will soon be making $200,000 for each monthly harvest of 250,000 oysters. A group of scientists formerly associated with Pryor plan to raise oysters and prawns on a farm in Hakipuu, O'ahu. Ed Otsuju is in the process of raising prawns in Hauula. Kenneth Kato has received funds to raise prawns, catfish, and carp in farms on Maui and O'ahu.

An aquaculture consultant to the State Department of Planning and Economic Development; Robert Schesser told Congress during testimony in July that aquaculture could be Hawaii's "fourth industry" because of its warm waters. Schesser is working in contract with DPED drafting a masterplan for Hawaii's future in aquaculture. The field will add jobs and millions of dollars to Hawaii's economy.

BIBLIOGRAPHY

Book

Bardach, J. 1968. Harvest of the Sea. New York, Harper & Row.

Loftas, T. 1970. The Last Resource. Chicago, Henry Regenery Company.

Michelsohn, D. R. 1974. The Oceans In Tomorrow's World: How Can We Use and Protect Them? 2nd ed. New York, Simon & Schuster Inc.

Waters, J. 1970. The Sea Farmers. New York, Hastings House.

Wolfe, L. 1972. Aquaculture: Farming in Water. New York, G. P. Putnam's Sons.

Article from newspaper

Altonn, H. 1976. "Fish Farming: Big Hopes, Limited Funds." Honolulu, Honolulu Star Bulletin.

Krauss, B. 1976. "Seafood time at plantation." Honolulu, Honolulu Star Bulletin and Advertiser.

Markvich, M. 1976. "Aquaculture Boom." Honolulu, Honolulu Star Bulletin.

MAKING AQUACULTURE WORK: PROBLEMS AND BENEFITS

by John E. Sisson, Punahou Academy

ABSTRACT

Aquaculture is a field which has a tremendous potential for growth. Although there are many problems in developing this resource; from land and water use, to types of fish needed for oundition to pollution and river control. There still is sufficient reasons for Hawaii to exploit its aquacultural potential. The reward for investing energy in this resource is the strong and real possibility that Hawaii can become protein sufficient and thus less dependent on imports. Hawaii's future depends on her ability to have this self-sufficiency.

A major step in man's civilization was that of the development of agriculture. The difference between the energy expended hunting for food and the cultivation of foood was enough for man to lay the first foundations of complex society. As Hawaii becomes, as it already has started, a complex state with a population of up to a million people, the same sort of advancement must take place in food production. Hawaii must stop the random hunting of fish and start the cultivation of them in order for Hawaii to achieve its full potential. Because, without this controlled use of fish, Hawaii can never approach the self-sufficiency it requires as an island state. To fully exploit the benefits of aquaculture and fish culture, we must examine the problems and advantages the establishment of aquaculture will have here.

The main point of aquaculture , or in this case fish culture, is to maximize the usuable product you can get from the available energy and materials. To do this most effectivly you have to control the full life cycle of the fish. You want to exercise this control for two reasons: one, to minimize losses from predators, disease, and starvation, and two, to make capture and use of the fish simple. To exercise this control you have to deal with the major problems of feeding, breeding and control of the fish's environment.

First, before we deal with the variables like fish type and breeding, we must deal with the basics that must be met to set up any fish farm.

Strangely enough one urgent need of the fish farm is land. Because it is the fact that the farm is on the land which allows the needed control of the life cycle of the fish. The land must be relatively flat for large area ponds, which are necessary for effective production. The land must also be close to roads or some form of transportation, because fish production is useless unless there is a way to get the fish to people. The major problem is that where there are large land areas, there is often no source of effective transportation or water.

Water, obviously is the most important thing to have for a fish farm. This means not only water for the fish to swim in but also flowing, oxygenated water to remove wastes and provide the fish with oxygen. This flowing water, need not only come from a river. As long as there is enough flow any source can be used, including tides, as in brackish pond culture, and pumps. The volume of the water flow is very important because it determines directly the size of your fish ponds. This means that if there is not enough volume of flow no matter how big or carefully you make your ponds, you can only support a fixed number of fish.

These basics in themselves are hard for Hawaii to solve because the two things that Hawaii lacks are land and large amounts of fresh water. But there is a solution, and that is brackish pond culture which requires much less fresh water and is usually situated as much as possible slightly off-shore in swampy land. This means that no one is downstream of the farms getting polluted water and very little "usuable land" is locked up in fish production. Also, river delta land in Hawaii is seldom in demand to begin with. The only problem with this system is that it depends on both river and tidal flow which means that when you feed the fish some of the food is lost along with the wastes washed out. This cuts down on your production efficiency.

Once we have the land and water problems solved we still have to find fish that will live in the environment we have set up and fulfill the necessary criteria for a successful brackish water aquacultural project.

One major criteria of the fish is that it must be efficient. In order for a farm to be successful you must get maximum growth on your crop within the first year or you will not be able to attract private investment and compete as well with other forms of food production. Along with a fast growth rate, the fish must be able to live in your environment, it must be able to eat the available food, grow, and breed in your brackish water environment. Some fish that fit these requirements have already been found as a result of aquacultural research in Thailand since 1959. Some possible fish might be: the Grey Mullet (Mugil species), the Bulan Bulan (Broussonet), the Milk Fish (Chanos chanos-Forskal), and the Sea Bass (Lates calcarifer).

One other criteria in selecting fish is to try to have fish that use a variety of food levels and sources. This means, if possible, to have fish that use different levels of the food chain in the same pond. Such as; surface feeders eating plants on the surface, producing excrement which fertilizes the water and the bottom. This fertilized water produces planktonic food which supports mid-water plankton feeders, whose excrement fertilizes the bottom along with the surface feeder's to support the bottom feeders who help to process the excrement and help provide nutrients for the plants (fig. 1). By using this method you can have a self-cleaning system as well as one which by producing on all levels can yield over 10,000 lb/acre.

One other thing to consider when establishing fish farms is that fish are more sensitive to pollutants than almost any other animal. This means along with a good supply of oxygenated water, the water must also be pollutant free. In Hawaii there are three major kinds of pollutants that could effect aquaculture. The most important of these is pesticides. Fish have such a sensitivity to them that as little as 1.5 parts per million of something such as DDT will cause death in 96 hours. And there are at least 50 insecticides and herbicides that effect fish, some in quanities as little as six parts in ten billion! Hawaii being strongly agricultural means that there is probably pesticides in all major streams.

Two other major pollutants that might effect aquaculture are detergents and suspended matter. A detergent concentration of more than 11 parts per million is fatal to all fish and the concentration can easily reach that at the mouth of a river where the fish farms would be. Along with detergents as a problem, there is the one of suspended matter in the water. Suspended matter is small particles like silt or fine dirt which cut down the ability of plants to grow by cutting out sunlight. It also clogs fishs' gills so they can not breathe. Suspended matter collects at the mouths' of rivers and is the result of erosion of soil and run-off from cultivated land.

To allow any fish farms to exist at the mouths' of rivers we must establish some sort of river management. Otherwise these pollutants plus others like metal salts, cyanides, and heavy metals will slow down or stop production and poison the crop of fish.

Fish, because of the fact they are cold-blooded, are very sensitive to any change in their environment especially in earlier life. This means that not only water and oxygen are taken into account when planning a fish farm, but also things like parasites, bacteria, pH, CO_2, and temperature must be planned into your initial structure of the farm. For example, when breeding fish the eggs must be kept in a well oxygenated, warm area. But the same conditions that help the eggs to hatch, also promote bacteria to grow on the eggs, often in a thick "soup" which weakens many of the eggs. Antibiotics must be added to prevent this "soup" from forming, yet just a little too much and you kill the larval fish, thus very strict control must be practised. Other conditions are also critical, such as the pH must remain between 5.5 and 9 and the temperature must never go above 35°C. Aquaculture is a lot more than just throwing fish in a pond and then harvesting them a year later.

Besides solving all these problems of conditions, there is one more major one that will have to be solved, the creation of a market for these fish. Tastes have to be changed so that there is a demand and a possibility for profit. Private industry must get interested and this can only be accomplished throught the use of subsidies and incentives by the state. Because, as I said, all aquaculture farms developed will be useless unless there exists people who want to and will market and eat the products.

There are many problems that must be solved but there are also at least three major advantages it would have for the state. One is, right now the state is limited by what it can catch and import for its seafood. If Hawaii has the capacity to be protein sufficient throught aquaculture, it will have the choices to control its growth instead of being limited by the non-controlable circumstances of fishing and mainland production. Hawaii tries to grow all its own vegetables, so it isn't as dependent on the mainland. Shouldn't Hawaii try to be protein suffient also?

Aquaculture is also more ecologically sound than fishing because it uses over-all much less resources. Less equipment and much less fuel are used compared to chasing after fish. And with oil crisies and other shortages, less is better. This also reduces dependency on the mainland.

And finally it is very good for the economic growth of the state. We use local labor and don't send money out of state for imports. To have more money kept in the state promotes economic growth in all areas of the state and that is very good for Hawaii. Hawaii needs to be less dependent on outside somrces for its food and economic growth. Plus we are using the resources of Hawaii for a change. Hawaii has some of the best area of any of the states for a large aquacultural program. We should and must use that capability.

There are many problems to solve to make aquaculture work in this state. Problems involving land, water, pollution, and the biology of fish have to be solved to make aquaculture a reality. But the benefits of increased self-sufficiency, economic growth, and conservation of resources can not be overlooked either. Hawaii has as many or more possibilities as any state and I feel that the best way to take advantage of these possibilities is to use Hawaii's resources for aquaculture. I feel by taking that step from hunting to farming, we will do more than just add a new food source, we will make this a better state for the future.

BIBLIOGRAPHY

Ardiwinata, R.O., Pemeliharaan Tawes , Bandung-'s-Gravenhage, Penerbitan Vorkink-van, 1961.

Bardach, Dr. John, Lecture, Nov. 12,13, 1976.(notes)

A Decade of Progress in Fisheries, Directorate of Fisheries, West Pakistan, Ferozsons Ltd, Lahore, 1963.

Fisheries in Thailand, issued by Department of Fisheries, Ministry of Agriculture, Bangkok, Thailand, Sept. 1961.

Jones, J.R. Erichsen, Fish and River Pollution, London, Butterworth and Co., Ltd., 1964.

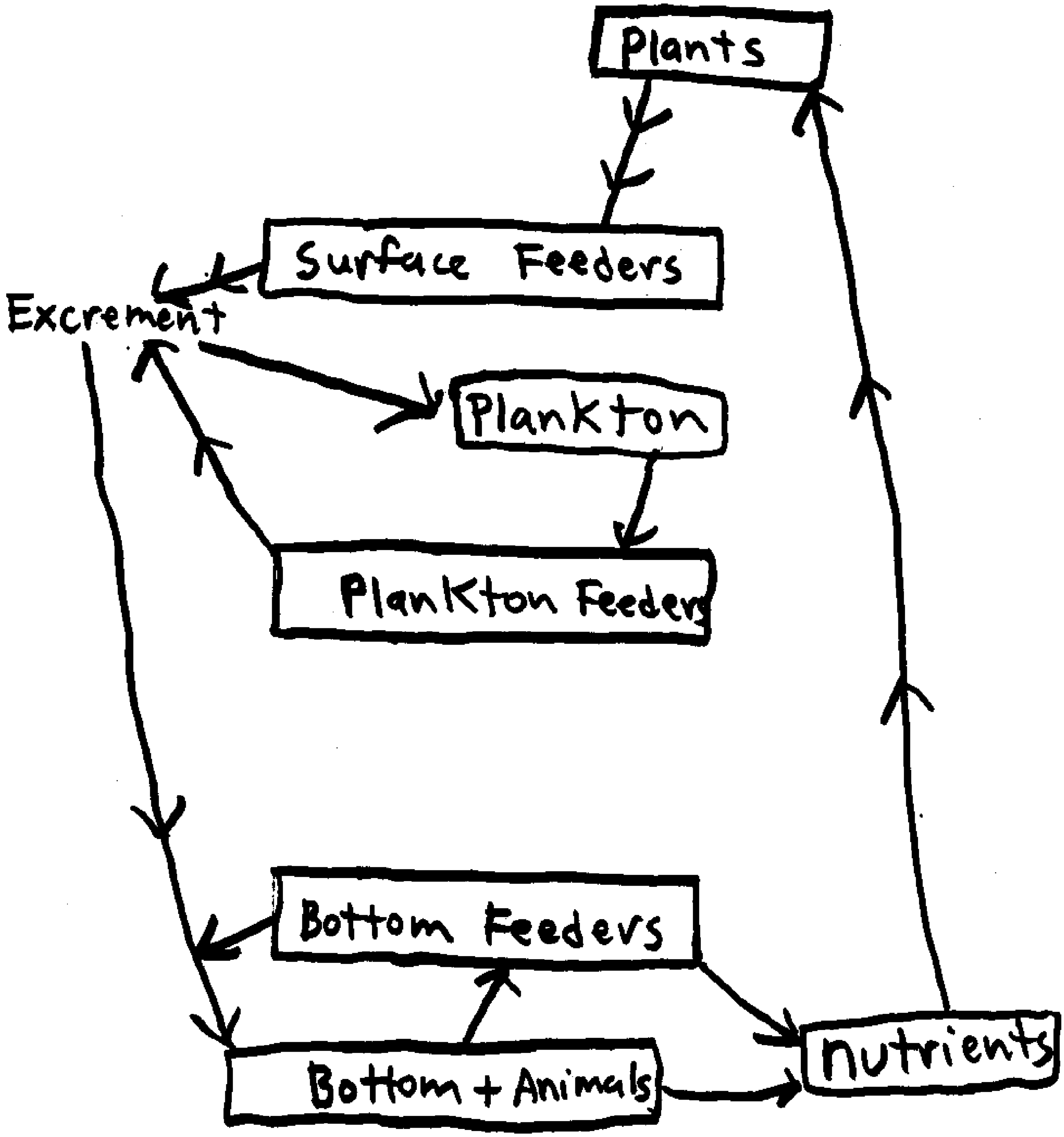
Lewis, William M., Maintaining Fishes for Experimental and Instructional Purposes, Carcondale, Southern Illinois University Press, 1963.

Loftas, Tony, The Last Resource: Man's Exploitation of the Oceans, Chicago. Henry Regnery Company, 1970.

McKee, Alexander, Farming the Sea, New York, Thomas Y. Crowell Company, 1969.

Ong, Kee Bian, Fish Culture, Borneo Literature Bureau, Asiatic Lithographic Printing Press, Ltd., Hong Kong, 1968.

Fig. 1



Plants
Surface Feeders
Excrement
Plankton
Plankton Feeders
Bottom Feeders
Bottom + Animals
nutrients

AQUACULTURE'S PROGRESSION: RESEARCH

by Holly C. Yamane, University Laboratory High School

ABSTRACT

At the moment, Hawaii's economy is supported by three major industrys: Tourism, federal expenditures and agriculture. But if, for the future, we wish to create new and different jobs, economic diversification for Hawaii needs to be obtained.

Aquaculture is not yet one of those buisnesses helping to support our economy, but it is growing and, when fully developed, could become our fourth industry. This is where research comes in. In order for an industry to grow and progress, to where it could be one with economic impact, you need to have the key, to having a productive industry, which is research.

Research can tell us how aquaculture can develop its potentials and technologies to where we'd have an industry that is not only producing more with less, but one which would also be a sound investment.

INTRODUCTION:

Aquaculture,when fully developed, could supply the needs of a sizable area of the State's market for aquatic foods as well as provide worldwide export products, such as prawns and oysters for Japan. Aquaculture could also help us to obtain greater independence from Mainland and foreign food import products. All this can happen through research.

Research in aquaculture is of two main sections. Research of production technologies, as well as research of the species themselves. These two sections are both quite inter-related as they both can have effects on each other, which in turn can affect your production rates. This is because certain characteristics of a species do determine what environment it is best raised in and it's up to research to take advantage of these factors and use them to their fullest potentials.

In this paper, I will be focusing mainly on the progression of our aquaculture research activities and how it has helped our industry to grow.

Research: Progression

There are several major organizations which are carrying out aquaculture research:

State Government: Department of Land and Natural Resources
University of Hawaii
Hawaii Institute of Marine Biology
College of Tropical Agriculture

Private Non-profit: The Oceanic Institute [1]

The Division of Fish and Game of the Department of Land and Natural Resources have scientists who are involved in research activities of aquaculture cooperatively with other State agencies and private individuals at many sites around the State, but the greatest effort has taken place at the Anuenue Fisheries Research Center. Division scientists have focused their attention on mainly determining the aquaculture potential of the Malaysian prawn and the oyster.

The particular species being investigated as well as the way research is approached is different for each of the four major organizations.

The Hawaii Institute of Marine Biology has evaluated many local species of shellfish and fish to determine their aquaculture potentials, but due to problems with nutrition, many of these candidates were dicarded. However the HIMB's program has been made over in order to concentrate its research efforts and development resources, on three species which show high commercial promise as aquaculture species:the Malaysian prawn, the topminnow (a tuna baitfish), and the moi.

The Oceanic Institute, who had been focusing its research efforts on developing the aquaculture potentials of the mullet, has widened its program to apply to other species the techniques developed in its mullet program.

The Anuenue Fisheries Research Center of the Department of Land and Natural Resources, had also been concentrating its efforts on only on species-the Malaysian Prawn. But thoughit's still focusing on cost-reduction in its Malaysian prawn-rearing system, they have expanded its research efforts in cooperation with the University , to attempt to solve the problem of artificially spawning catfish and grass carp in Hawaii.

Looking at Table I can give you a look at the current standings of our aquaculture research activities progress. These critical research areas are all very important, as they are necessary for the progression in the cultivation of a species. The summations at the bottom, show the degree of progress in each area, and although the areas are all listed separately in the table,they are actually , in practice, highly inter-related.

The area in which the greatest progress has been made is the spawning of animals in captivity. This is because of the sucess we've gotten in having prawns, moi, and topminnows

Table I. -- Status of Current Aquaculture Research Activities in Hawaii

Lead Organization	Species	Spawning in Captivity	Larval Rearing	Juvenile to Market Size Rearing	Behavioral Research	Nutrition, Food Requirements and Formulation	Disease in Rearing Schemes	Genetic Selection Experiments	Facilities Engineering	Production Economics & Marketing	Species Degree of Progress
DLNR	Prawn	3	3	3[a]	2[b]	3[b]	2[c]	2[d]	3[c]	3[b]	24
	Carp	2	2	1	1	1	1	1	1	1	10
	Catfish	2[e]	1	1	1	1	1	1	1	1	10
HIMB	Moi	3	2	3	1	2	2	1	3	2	19
	Topminnows	3	3	3	2[e]	3	2	2	3	3	24
OI	Mullet	3	2	3	2	2	2	1	2	2	19
	Milkfish	2	2	2	1	2	1	1	1	1	13
	Reef Fish	2	1	1	1	1	1	1	1	2[e]	11
Research Area - Degree of Progress (totals)		20	15	17	11	16	12	10	15	15	

(Highest possible degree of progress for a species is 27; lowest is 9; similarly for progress in a research area, highest is 24; lowest is 8.)

3 = Advanced phases of research - Perfect and/or reduce cost of techniques (make acceptable results better).
2 = In initial phases of research - Development of techniques to give acceptable results (good survival, fast growth, etc.).
1 = Species selected for study - Research will begin when sufficient numbers of animals or basic preliminary data become available.

a = with HIMB and College of Tropical Agriculture
b = with HIMB
c = with College of Tropical Agriculture
d = with Genetics Dept., U. of H.
e = with Zoology Dept., U. of H.

spawn naturally in artificial enclosures, and inducing mullet to spawn with hormone injections. But in trying to arficially spawn moi with hormone injections, we were only partially sucessful:some eggs were produced and a few individuals were raised from eggs to the juvenile stage. A significant discovery was made when it was found that moi would spawn spontaneously while being held in suspended net enclousers. The fertilized eggs could simply be harvested by filtering the enclosed sea water.

The next most advanced area is the growout experiments with juveniles. There was some sucess with moi and mullet, but with the mullet ther was a lack of consistent results, such as high survival and rapid growth rates. However, a good reproducible amd economically feasible methodology for the Malaysian prawn's growout phase,which is from the small juveniles to market-size prawns, has been developed,as we can see from the small yet visible commercial prawn industry that has developed here in Hawaii.

Nutrition, food requirements and feed formulations, is an area which has gotten a great deal of attention in the past, and is the next most advanced area of research. Nutrition can have effects on the economy of aquaculture in several ways:one way is that an animal which is in nutritionally poor condition, can be more vulnerable if a change inthe water quality was to occur, than a well-fed, nutritionally healthy animal. In keeping the animals healthy,you'd be ablee to protect against product-ion loses.The improvements of natural and artificial feeds could also increase and enhance the commercial yeilds, as a high-quality diet could give you more rapid growth rates. Feed costs can also be a limiting factor in the economic success of meat-eating aquaculture species, for it can make up half of the total cost of producing a crop. Therefore the need for inexpensive feed formulationsis clear.As with the Melaysian prawn, in efforts to increase production rates, while at the same time reducing operating costs, research efforts turned to the formulations and testing of an inexpensive prawn feed which was also practible for a full-scale commercial prawn operation.

Our next most advanced areas of research are larval rearing, facilities engineering and production economics and marketing. Some of the primary aquaculture species in Hawaii, such as the marine species(moi, mullet,and milkfish) don't have consistent supplies of juveniles available for stocking purposes due to variations in larval suvival. But there are well defined and reproducible rearing techniques for the prawns and topminnows, the other primary aquaculture species.Six years of research efforts,by the Dept, of Land and Natural Resources, has resulted in the develop ment of a practical mass rearing technique for the giant fresh-water prawn, and its current inventory stock can adequately fulfill the needs of a commercial operation of any size in Hawaii. Facilities engineering, production economics and marketing studies don't have very high levels of progress as they are quite recent as compared to the other areas. Production economic studies are particulary limited because the necessary research data such as costs of food, juveniles, growout, etc., are not available from the other research areas yet. But a comprehensive larval rearing-cost evaluation made from the FY 1968-69 period, showed that the cost of producing prawns of 8mm average length, was about $6.63 per thousand (fixed costs, such as ammortization of capital outlay, taxes, etc., not included). Labor accounted for about 77% of the total cost, clearing indicating that the reducing of labor costs would bring about a major lowering of production costs. During FY 1969-70, attempts to reduce labor outlay were made by using much larger larval rearing tanks (18,927 instead of the 908 to 1,514 liter tanks used in FY1968-69). Although, with the larger tanks prblems such as water quality managment and temperature and sunlight control did occur, the total cost of producing 1,000 juvenile prawns was reduced to $1.93. Marketing studies for various aquatic products could be, but not have been, carried out due to the lack of financial support.

The least advanced areas of research are disease in rearing schemes, behavioral research and genetic selection experiments. After significant progress has been made in the other research areas is when these areas usually come into greater development.At the moment, except for the Malaysian prawn and topminnows, there is no work being done to begin experiments to find the solutions to the key problems in these areas,Further investigation of the already known diseases is needed so we' be able to determine causes,methods of diagnosis, treatment and control measures for prawn diseases.

At present, research on diseases of prawns and other aquaculture animals had led to the identification of several pathogens as well as the formulation of two working hypothesis on the disease mechanisims in prawns. [2]

Behavioral research is also needed as it can help to determine what the effects of stocking density and body size on shelter use and movements are, and as with the Malaysian prawn, the amout of agressive interaction between prawns can determine the rearing density, which can in turn, haveeffects on prawn production.

The most important area could be genetic research. Selecting and breeding animals with the most favourable characteristics, such as:fast growth rates, disease resistance, shorter larval life, etc. is needed for reduced costs and the final domestication of an animal species.

Sucessful genetic research is the all important "bottom line" item of the research areas.[3]

Our Aquaculture Industry's Growth:

Aquaculture has developed to the point where over $1 million is spent annually in the State for research and development. Through our scientific discoveries, our aquaculture industry has suceeded in producing more with, less, as well as helping the rest of the world with our discoveries and technological advances.

And so , as of now, because of the research and development work done, Hawaii has an economically viable, growing aquaculture industry. Aquaculture has the potential,as as industry, to go a long ways, and research is what has been discovering the technologies to bring us this far, and it can take us further. Without the advancement of our methods and knowledge, there wouldn't be any progress.

Summary:

Research has shown aquaculture the way to a productive, yet practical industry. We have discovered the species which do have aquaculture potential and we are now trying to make the fullest use of these potentials.

And now that the industry is picking up, it'll need more support. We need to improve what we have as well as develop new and better technologies. Once again you'll have to look toward research.

FOOTNOTES

1. John S. Corbin, Aquaculture in Hawaii 1976, Hawaii,1976, p.33.

2. Ibid., p.57.

3. Ibid., p.10.

4. Ibid., p.8.

BIBLIOGRAPHY

Corbin, John S., Aquaculture in Hawaii 1976 -an assesment prepared for the Department of Planning and Economic Development, State of Hawaii, January 1976, pp.1-60.

Ling, S.W., The general biology and development of Macrobracium rosenbergii (de Man) ,Ciudad de Mexico

"Fish Farming: Big Hopes, Limited Funds.", Honolulu Star Bulletin: Progress Section 1-Land, Febuary 22,1977,p.16

Fujimura, Takuji, Development of a Prawn Culture Industry in Hawaii,(Commercial Fisheries Research and Development Act-Job completion report),June 30,1974.

THE AQUACULTURE OF MACROBRACHIUM ROSENBERGII

by Stephanie Cunningham and Alfred A. Calantoc, Pahoa High School

I. Characteristics

Macrobrachium Rosenbergii, the giant, long-legged prawn of brackish and fresh watess, has been highly esteemed as food by peopleof the tropical countries of Asia and the Far East. The popularity of the Malaysian prawn has grown rapidly and its demand is progressively enlarging. Therefore, methods for increasing the production of the prawns are necessary in order to meet the needs of the vast and ever increasing multitudes of people.

The giant Malaysian Prawn, Macrobrachium Rosenbergii,known as "Udang Galah" in Malaya, is distribute widely in most of the tropical and subtropical areas of the Indo-Pacific Region. The Indo-Pacific Region includes East Pakistan, Ceylon, Burma, India, Philipines, Cambodia, Indonesia, Thailand, Vietnam, and Malaysia. The prawn thrives in both fresh and brackish waters and occurs all year round. Prawns are inhabitants of most rivers, estuaries, and especially lower regions that are influenced by tides. Prawns can be found up to at least 200km from the coast, and present in lakes, water reservoirs, mining pools, irrigation canals, and some paddie-fields which have direct or indirect connections to rivers.

In both stages, adult and larval, the prawn is euraline to a considerable degree. In its natural environment, the prawns spawn in brackish water and the juveniles travel upstream to fresher waters. Larvae hatched in 3 to 6% brackish water are able to tolerate an immediate transfer to any water less than 21% salinity without serious losses. The best larval stage salinity to close to 12 or 13%.

Larvae need saline water for survival, but juveniles and adults are able to freely move to fresh; or if maintained in brackish, they apparently continue to do well.

The question of salinity is imp obtant because fresh water supplies in many regions are limited. Continued experimentation to determine survival and growth under a

> spectrum of salinities has the potential of opening up large areas for prawn culture in estuaries in protein-short tropical countries.[1]

Temperature appears to be a more important factor than salinity. Larval Prawns are sensitive to temperature. The preferred temperature for larval rearing is widely agreed by culturists to be at 28 degrees Centigrade.

After becoming 60-day old juveniles, the Malaysian Prawns can survive wide temperature variations. At one extreme, adult and juvenile prawns survived 16 degree centigrade temperatures for several days, and with some deaths but not totally lethal at 14°C. At the other extreme, 35°C is given as the upper lethal limit. The optimal range is about 30-31°C with 29-33°C being acceptable. A narrower range was given as 28-30°C as practical, 30°C as th maximum, and 29°C as optimal.

Malaysian prawns are aggressive and cannibilistic as are most crustaceans. Among freshwater species, the Malaysian prawn is one of the least aggressive and not too highly cannibilistic.

Malaysian prawns have been raised successfully in fiberglass, concrete, plastic and ceramic tanks, aquaria, swimming pools, and ponds with earthen bottoms. Usually a substrate is added for aid in the protection of prawn larvae. The substrate assists in reducing predation and cannibalism.

Macrobrachium Rosenbergii breed and spawn easily and readily in a suitable environment.

After comparing other species of Macrobrachium with M. Rosenbergii, it was concluded that the Malaysian prawn is by far the superior animal for culture.

II. BREEDING THE MALAYSIAN PRAWN

Healthy mature prawns breed year round in a proper environment. There is little difficulty in maintaining the brood stock in tanks or ponds and ripe females are selected when needed.

Mature females are ready to breed after they complete a pre-mating moult. Ripe ovaries are visible in the female as large, orange-colored egg masses located in the dorsal and lateral parts of the cephalothorax. The abdominal pluera are distended slightly and arched outward to enlargen the brood chamber.

A typical mature female can produce up to 6 [illegible] eggs. Larger females can lay eggs twice in five months and sometime more often.

When females are placed in a tank without the presence of any males, a female that may have just completed a moult is subject to being attacked and killed by other females within the same tank. With a male present, he protects the vulnerable female from attack. One male can protect five or six females at one time.

After mating, six to twenty hours later, the eggs are extruded. The time in which it takes the eggs to be extruded depends on how early after the pre-mating moult the actual mating takes place. The eggs are attached to the pleopods of the female where they ripen. The eggs slowly change as the larvae mature to the hatching stage. The larvae are fully developed within 16 to 17 days. The eggs hatch on about the 19th day. The unmated females also extrude eggs but the unfertilized eggs drop from the pleopods in a few days.

The berried females are held in salinities of [illegible] to 1[illegible] until the eggs finally hatch.

III. FROM EGG TO POST-LARVAE

Methods of raising M. rosenbergii larvae from egg to post-larvae have been well established. Due to the fecundity and the ease of holding substantial brood stock, occasionally culturists are capable of producing more post-larvae than they are able to stock and grow sufficiently.

Prawn larvae continue through eleven stages after hatching. Only eight of these stages are noticeable without the aid of closer examination. The larvae are planktonic during their larval development. They constantly feed during this period. They are strong swimmers, moving with their tail first, head down, and their ventral side upward. Until they reach ten days of age, they swim closely congregated, just under the surface of the water. After 10 days, they slowly begin to kisperse through out the pond from their "togetherness"

As the larvae approach metamorphosis, they tend to jump and maybe stranded up out of the water. Mosquito screening was applied to the edges of the tank and proved to be the solution for this problem.

Since the larvae are planktonic, they require food particles to be suspended about the water until completely consumed. Certain equipment such as perforated air tubes, air stones, and specially designed tanks with properly circulated w water have been used with great success.

Live food (e.g. Artemia Nauplii) and suitable sized particles are the preferred substance of the larvae. Larvae swim while eating and catch their food with the maxillepeds and thoracic legs.

The larval growth rate is somewhat irregular after the first three stages among individuals. During the first two stages, the egg sac is still attached to the larvae, providing food for them. Feeding during this period is considered unnecessary.

In 1 to 18 days, the first metamorphosis into post-larvae can be expected. The temperature should be at about 29°C and salinity at 12%, withan adequate food supply. Factors such as temperature, salinity, density, and food determine the time it takes the larvae to complete metamopphosis. Larval development has been reported to take from 30-45 days. Prawn larvae are euryhaline and can tolerate up to 21% salinities, but a 12% salinity seems most desirable for the larvae.

IV. JUVENILE PRAWNS

Depending on temperature and other factors, 18-45 days after hatching, the larvae complete their development. After metamorphasis they resemble adults in appearance and general behavior. They are no longer planktonic and settle to the substrate and become crawlers.

During this stage the larvae are still referred to as post- larvae(PL), although distinction between PL and juveniles is a matter of size. They are usually called PL for about 60 days. During the 60 day period they moult every ten days, grow rapidly, and can attain a length of 5 centimeters.

The transition period from PL to juvenile is a vulnerable time for the prawn. The baby prawns settle to the bottom or cling to objects and are subject to aggression or cannibalism from fellow prawns. Predation by such creatures as dragonfly nymphs is also a threat. Shells, twigs, and other objects suffice as proper substrate and reduces casualties.

During the two month period the juveniles increase their hardiness and can tolerate variable temperature changes.

Juveniles can be stocked in ponds or grow-out facilities where temperatures are suitable for growth, such as tropical regions. In temperate zones, it is preferable to maintain juveniles in rearing tanks for longer periods until temperatures become suitable, usually in late spring.

Feeding juveniles may not be necessary for the first 120 days if the ponds have a sufficient supply of natural foods. However an abundance of natural fertilizers are required for pond fertilization. This practice may be applicable in tropical regions mainly.

Denaity is a major factor in the mobtality of stocked prawns. A density of 12-18 juveniles per sq. meter, with an average of 15, results in a 50% mortality rate. Lower densities produce higher survival and more rapid growth but also alower harvest. Higher densities result in both lower survival and growth rates.

V. FEEDING CULTURED PRAWNS

A critical factor in the cost of prawn production is food. Two-thirds of the principal food cost is during the grow-out stages. When the prawn is growing to marketable size. "Depending on the type of grow-out system used, profit may be very sensitive to food costs to produce prawns of a given size. There was a consensus that much additional research is needed on food requirements of prawns 20 grams and up."[2]

Characteristics of an optimized prawn food for grow-out to marketable size are as follows:

a) Costs as little as possible.

b) Provide sufficient growth.

c) Remain stable without leaching of nutrients for up to 24 hours.

d) Be handled with ease and convenience.

e) Have a long shelf life.

f) Contain materials that cost and supply don't fluctuate too drastically.

g) Desirable to the prawns.

h) Be disease free and non-toxic.

A specified diet requires 75% animal protein and 25% vegetable material high in starch. Young prawns grow best on binders containing high amylose starch. In Asia, soybean curd was reported to be very successful in larval culture.

Juveniles are usually stocked in grow-out systems after 60 days. Ponds are most commonly used and some culturists use tanks. The prawns are fed adult rations. Various types of foods are being used successfully such as chicken broiler starter, catfish pellets, Ralston-Purina's experimental Marine Rations, trout and shrimp chows, and Oregon moist pellets.

Most prawn grow-out is done in earthen ponds. With outdoor ponds, there is a normal algae bloom, zooplankton population, and both animal and plant life existing on the pond bottom. "There is no doubt that the normal productivity of a pond makes a contribution to prawn growth, but the percentage of food the pond provides is unknown."[3]

Present feeds produce prawns of satisfactory quality, but there is still a need for improvements. Besides inducing satisfactory growth, the food should also result in excellent texture, flavor, and color.

VI. DISEASE

Freshwater prawn culturists have had fewer difficulties with disease than culturists of other crustaceans. The Macrobrachium species appears to be very strong and disease resistant. Nevertheless, complications have occured and will probably keep on occuring.

> A past difficulty has been a lack of experienced diagnosticians in key locations, and there is some opinion among culturists that transient diseases have caused prawn kills without emerging as serious problems and without being diagnosed.[4]

One of the few infections that has, so far presented problems to M. Rosenbergii is a disease known as"black spot". The solution was to increase water flow and remove residues of uneaten food. Later, the addition of 3% salt was found to be effective.

Causes for prawn susceptability could be water quality, lack of algae, intense light exposure, inadequate diet, and high pH, all of which lower the prawns resistence and cause stress and fatigue.

In spite of the few wipe-outs, disease is not considered to be a major obstacle to overcome in commercial prawn culture.

VII. PRAWN SYSTEMS

Suitable systems for prawn culture depends on the area in which the operation is to take place. There must be sufficient supplies of land and high quality water. There is no agreement on the amount of land that is needed to sustain a commercial enterprise. It has been stated that anything under a thousand acres is too small for a major enterprise, with ponds occupying two-thirds to three-fourths of the area. Essential quantities of water, depending on the flow rates, could be as much as 10 million gallons per day. Other elements like capital costs would hike accordingly.

Prawns can be cultured successfully in ponds, raceways, troughs, and tanks. Open flow-through systems, recirculating systems, and partially closed systems are suitable. Prawns can be culture as a single crop, or with a combination of other animals in polyculture systems. Culturists may depend on natural temperature or they may increase them by the direct application of energy, solar heaters, and the addition of thermal affluent.

Earthen ponds have been profitable and most successful in prawn culture. Production ran er from 2500 to 4000 pounds per acre per year.

The size of the prawn is usually determined by the ease of harvesting and pond maintenance. Common sizes are half-acre and acre, though there are many variations. One-tenth acre ponds have been used to hold brood stocks.

There are two methods for harvesting, draining and seining. Draining is the most feasible and requires less labor.

If a 50% mortality is to be expected, then the ponds must be stocked with twice as many juveniles than are to be harvested.

VIII, PROCESSING AND MARKETING

Market si e and elasticity for Malaysian prawns is unknown. Some markets with limited supplies bring premium prices. In Hawaii, wholesale prices are from $3.00 to $3.00 per pound, heads on, with the retail prices at $4.50 to $4.95.

Malaysian prawns are highly perishable. For long shelf life, killing the prawns by flashfreezing, and then holding them at a constant -30°C was recommended. Lower temperatures are better, because the ice crystals are smaller and tissue damage is reduced.

The fresh product is in greatest demand. To maintain their good condition the prawns are blanched before iced. The technique requires the prawns to be chill killed, blanched at 150°C for 15 seconds, and then re-iced. The entire process takes less than a minute per batch of prawns. The result in the technique is a 6 day shelf life.

IX. ECONOMICS OF PRAWN CULTURE

In Hawaii, the cost of raising prawns to market size is presently about $2.00 per pound. The costs of feeds are about 42 cents per pound of prawn produced. Labor costs are estimated to be from 30 to 40% of grow-out costs, and the feed at 22%. In order to reduce costs of grow-out, machine labor must replace hand labor to the greatest extent possible, and a less expensive feed is definitely needed. Another possibility is to increase the survival from the normally accepted 50%.

Since Prawns are presently somewhat expensive, there poses a question of what will be the market for luxury foods during a serious, world-wide recession or depression, if such were to occur.

It seems apparent that the freshwater prawn industry will not be able to support mass market culturing until the market is large enough to sufficiently match the demand and decrease the cost.

X. CONCLUSION

Although hatching technology and procedures in culturing are adequate now to supply and support small localized enterprises, they still require improvement to achieve higher volume and year round post-larval culturing at much lower costs. Refinements should seek to utilize natural energy and nutrients in order to avoid such heavy dependencies on the rising costs of power and feeds.

Feeds and nutrition are of major importance in the conclusion that grow-out economics are probably the main goal to overcome in the culture of Macrobrachium. More work should be done on the animals themselves in order to find out their nutritional requirements while looking for better and cheaper feeds. The pond in which they grow should be studied much more intensely to understand the ecological relationships between the two. If an energy balance was met between prawn and pond, it might quickly reveal not only better nutrition but easier and

Cheaper pond management. Controlled experiments and pilot operations are required for such needs.

Problems in health and disease in M. Rosenbergii have been few and minor, so far. The ones that have risen have been treated successfully. However, it is eventually possible and expected than more complications will surface as higher density culture is achieved. It is suggested that a disease reporting system be established and a Macrobrachium pathology center be created.

In culturing, experiments with power plant cooling water effluents should be perfected. Experimental culture systems should develop advanced techniques in mass culture as a public service, government funded of course. Efforts should be accomplished by attempts to achieve primary improvements in the cost and effectiveness of prawn culture syltems and pond ecology.

The question of prawn culture economics has several prospectives. One would be if it were wise to go ahead with the development of a cultured luxury food when threatened with recession and depression. Cultured crustacea may be the only way left to satisfy the demand as the world reaches the maximum yields of wildstock that is sustainable. A futuristic perspective is that a cultured product with low man-made energy products as beef feed-lots. Market size is determined by the wholesale price of the prawns; hence, cost-effectiveness on grow-out is an absolute must if freshwater prawns are ever to become an industry of economic significance.

If time, money, research, and much determination are put forth by culturists the Malaysian prawn may turn out to be one of aquaculture's major breakthroughs in farming our waters. If man can master the art of growing all his food, putting to use the full potential of his resources, there may never be another starving, protein deficient body on this earth. The successfull culturing of Macrobrachium Rosenbergii is a positive step toward a goal of universal contentment and satisfaction.

FOOTNOTE PAGE

[1]Harold L. Goodwin, The Aquaculture of Freshwater Prawns, (Hawaii: The Oceanic Institute, 1974), P.4

[2]Ibid, p.19

[3]Ibid, p.22

[4]Ibid, p.23

Bibliography

Goodwin, Harold L., The Aquaculture of Freswhater Prawns, Hawaii: The Oceanic Institute, 1974.

MARINE RESOURCES:
MANGANESE MINING

MANGANESE NODULES IN THE PACIFIC

by Galen H. Kuwamoto, University Laboratory High School

Reported information on the following...
Introduction:
Part 1 - Hawaii a natural for nodules and diagrams of location
Part 2 - Metal content of nodules and values and impacts and diagram
Part 3 - Deep Sea Mining System (hydraulic system/cable line bucket) and diagram
Part 4 - Japanese program for maganese nodule exploration
Part 5 - International laws to keep sea mining
1) Existing rules of international law
2) U.N. Deep Sea Committee prospective issues in a legal regime.

Introduction

The widespread occurrence of ferromanganese nodules and crusts has been known for many centuries. Our understandings of their distribution and values can be credited to the efforts of the men who participated in many early oceanographic voyages. Included are the expeditions of the Challenger, Albatross, Vityaz, Eltanen, Vema, Horizon, Atlantis, and others.

Realization of nodules contents came about through a case study conducted in 1957 and 1958 by the Institute of Marine Resources of the University of California. A large haul of nodules, rich in Cobalt, nickel and copper was dredged from the Tuamotu escarpment, just east of Tahiti. The program was conducted by the scientists from the Scripps Institution of Oceanography as part of the 1957 International Geophysical Year Program.

Based on their oceanographic data, a broad band of ferromanganese nodules beds, rich in natural raw metals, lies 500 miles south of the Hawaiian Islands. This puts Hawaii the closets to many of the deposits and midway between major markets in Japan and the United States. Hawaii will play a major role in mining this valuable resource.

In 1958 the German research vessel Valdivia conducted a oceanographic spectroscope analysis (high-resolution x-ray photo emission of ocean floor) of nodular sea beds in the Atlantic and Indian Oceans. Based on the Valdevia data charts, nodule beds were patchly distributed throughout the ocean, but large amounts of ore was found. Manganese encrustation was restricted only to the upper surface of nodules with the underside free from manganese. This suggests the nodules were in a region of rocky terrain and strong tidal currents, and not in low sedimentation areas and calmer waters where they thrive.

Generally manganese crustal thickness was in the order of 1mm. The rate of accretion was from 1-10mm per 10^6 years. Their findings put the North Pacific Ocean a better means of resource compared to that of the Indian, Atlantic Ocean regions.

Hawaii, A Natural For Nodules

Hawaii is a "natural for nodules" and a number of research reports indicate Hawaii is the heart of a vast undersea region in which these nodules are most plentiful. There are at least four major reasons why Hawaii is a "natural" for manganese research and related studies.

Our geographic location is the center of a great ring of Pacific Nations is the most obvious one. During the turning point, Hawaii was once a great center for whaling fleets and oil tankers, also during Pearl Harbor, they used the base for a naval shipyard and military and naval base complex. Today an increasing amount of marine services with a new oil refinery for serving foreign bottoms has been built, also an encouragement of the use of harbors for more economical transshipment of goods by surface and air to other ports has been proposed.

Because of its central location, Hawaii is a logical point for providing services to vessels and their crew, research and development, and possibly processing of nodules. Also another main point to take under consideration is the active volcanoes. There are indications that the formation of nodules is somewhat based upon the presence of volcanic materials.

The second reason Hawaii is important is that we have a strong foundation of of technical expertise and facilities in our island. Many people may think of Hawaii only as a tourist center and an agricultural state. However, Hawaii has a number of internationally known research centers such as the Hawaii Institute of Geophysics, the Hawaii Institute of Marine Biology, the Institute for Astronomy, and the Bishop Museum.

This strong technical base makes Hawaii an ideal research and development center for manganese nodules, especially for the study of the causes of nodule formation, for deep-sea testing, and for processing technology.

The third favorable factor about Hawaii is our tradition of using science and technology in an innovative and sophisticated way. In agriculture, for example, Hawaii has been a leader in the development of sugar cane and very advanced methods of growth and harvesting. Also continued studies of ways to convert volcanic magma heat into low cost power has been developed and under more research. Possibly in the near future we could use geothermal energy to process manganese nodules for low cost operating fees and high capital and gross income.

The fourth factor favoring Hawaii as a center for manganese nodule work is our "Foreign Trade Zone", part of our Department of Planning and Economic Development. It is one of seven such Zones in the United States. Material may be landed and processed, and the original or processed products shipped to other countries without payments of import duties. The Trade Zone has other special attractions and incentives for international commerce.

Metal Content of Nodules and Values

At the present time, a conservative estimate indicates that there are some several hundred billion tons of mineable nodules in the high grade areas of the Pacific Ocean. The highest grade of nodules yet discovered and reported is found in a deposit about 1000 miles south of Samoa. Nodules from this deposit will yield about 1.9% nickel, 2.3% copper, 0.2% cobalt and 36% manganese on a dry weight basis. Deposits of the nodules can be found in other areas of the ocean which are as high as 2.6% cobalt or 55% manganese. In general, the chemical composition of the nodules is very uniform over a large distance of the Pacific; however concentration of nodules can vary.

The highest concentration of nodules presently known is about 100 kilogram per square meter of sea floor which would work out to be about 300,000 tons per square mile.

An average concentration in a deposit considered for mining would probably be in the range of 30,000 to 25,000 tons per square mile of sea floor.

The average size of the nodules is about 4 centimeters; however each deposit may vary with sizes ranging from 1 to 20 centimeters. The largest size nodules everdredged was approximately 4 feet in diameter.

Although deposits of manganese nodules can be found in almost all depths of water, only those deposits lying below about 3,000 meters are presently being considered as economic to mine. High grade nodules are generally found at depths ranging from 4000 to 6000 meters.

On a Pacific Ocean-wide basis, it has been estimated that the nodules are forming in the ocean at the rate of about 10 million tons per year. This rate exceeds the present rate of world consumption of valuable raw materials.
In fact, generally, on land mineral deposits are considered as depleting resources. In the ocean though we find that many of the mineral deposits of economic value, including deposits other than manganese are a valuable and pollution free resource.

One major point and advantage in considering the nodule deposits on the ocean floor is it will represent a means of reducing pollution of the atmosphere by permitting the closing down of many pollution prone, land-based sulphide mines and possibly, by the use of the nodules it will serve as a removal for sulphur dioxide power plants.

Deep Sea Mining Systems . . .
Hydraulic System and Cable Line Bucket

Although numerous systems have been tested for the recovery of nodules from the ocean floor, only two appear to have any economic standpoints.

The <u>hydraulic system</u> generally consists of a pipe which is suspended from a surface float or vessel; a gathering head, designed to collect and winnow the nodules from the surface sediments and feed them to the bottom of the pipeline while rejecting materials; and some means of causing the water inside the pipeline to flow upward with sufficient velocity to suck the nodules into the system and transport them to the top.

There are two hydraulic dredges being considered: conventional centrifugal dredge pump and air life pump.

Capital investment in both systems presently being planned or under construction range from about 30 million to about 60 million for systems capable of handling and recovering about 1 million tons of nodules per year from depths as great as 18,000 feet of water.

The estimated operating cost of these system range from $10 to $20 per ton of nodules.

The overall economic use of a hydraulic system, in general, indicates a total capital investment of at least $30 million. The process plant investment costs $75 to 100 million capable of handling 1 million tons per year. Total capital investment of nodules mining and processing would be $135 million.

Such a venture could produce about $67 million worth of products with a recovery efficiency of 90% the operating cost would be about 39.3 million per year, yielding a gross operating cost profit of $27.7 million per year and allowing a gross rate of return of 21% per year.

The second type of system, presently being planned for full-scale production is a Mechanical, Cable Line Bucket (CLB). This system basically consists of a loop of cable to which is attached a dredged bucket at 25 to 50 meter intervals; a traction machine on the surface vessel capable of moving the cable such that the buckets descend to the ocean floor along one side of the loop, skim over the bottom filling with nodules then returning to the top.

Operating the CLB system is relatively minor with capital costs in the order of 2.5 million, this includes exclusive cost of the surface vessel which can recover about 3 million tons of nodules per/year, the operating cost per ton would be $.50. In addition to being very simple to operate, the CLB can work at any depth and can recover any size nodule. (Note: system will be located aboard vessel with access to repair.)

The use of the cable line bucket will produce the nodules at a rate of 3 million tons per year and would have capital investment of $20 million.

This operation would produce about $52.1 per year worth of products, with a recovery efficiency of 70%. Operating cost would be estimated about 18.3 million per year, yielding a gross profit of $33.8 million for a 169% rate of return investment.

On the basis of impact analysis the hydraulic dredge pump will . . .

1. stir up sedimentation on ocean bottom
2. effect organisms and their habitats
3. growth of phytoplankton as a result of stirring up bottom

Reasons for . . .

1. efficiency rate of recovery higher - 90%
2. capital investment higher than CLB
3. gross net profit higher than CLB
4. reduce pollution on land than CLB
5. made for large hauls

Against . . .

1. effect marine bottom
2. cost to operate higher than CLB
3. system only capable of recovery at certain depths

Impact analysis for Mechanical, Cable Line Bucket . . .

1. no measurable effects to ocean floor
2. may harm bethnic organisms and their habitats
3. no growth of phytoplankton

Reasons for . . .

1. low in price to operate
2. gross net profit of return investment higher
3. gross net operating profit higher
4. no measurable effect to ocean floor
5. can go to recover any depth

Against . . .

1. recovery rate lower - 79%
2. can only take so much in one haul

More tests are to be done in the future to provide the best understanding of each system and to get the best economic results from it.

Japanese Program for Managanese Nodule Exploitation . .

Japan is an island country, and its limited land resources cannot house its rapidly growing industry. Most of Japan's copper and copper ore is imported and all of her nickel and nickel ore is imported. The price of both of these raw materials has decreased but in Japan the prices have increased.

In examining future nickel, copper, cobalt and manganese resources, deep sea nodule mining has a great potential interest to Japan, and Hawaii is nearer to Japan than its importer New Caledonia where most of her materials come from. Manganese nodules can absorb a great amount of sulfur dioxide which is the main cause of pollution in Japan.

Industry produces severe pollution in Japan. Power plants, especially, use oil which is rich in sulfur. This is why it's so polluted.

A Japanese University ship and a study team visited the United States under the direction of Dr. John Mero of Ocean Resources, Inc., La Jolla, California. Japanese companies organized a test near Tahiti using a 1,300 ton ship. The test was a complete success using the CLB at a depth of 3.675 meter (12,000 feet). This sparked a major proposition in Japanese Nodule mining.

Dr. Mero estimated it would cost approximately: $16 per ton using the CLB. If there were 500-1000 tons of nodules per day from 5,000 meters using a 20,000 ton Japanese ship it would cost daily:

ship charter	$5,000
CLB ($1 million; 3 year depreciation). . . .	1,000
other fees	2,000
TOTAL PER DAY	$8,000

Nodule dredging as a future business will be very beneficial to both the United States and Japan. So far, one line dredging was the only means of getting samples from the deep sea until recently, so the nodule supply was limited in amount, and they could not test it in large quantities.

Japan and several companies are testing several modified means to recover nodules with the Cable Line Bucket. These are some of the ventures underway in Japan. . .

1. build new surveying ship by 1975
2. conduct a nodule survey by that ship beginning in 1976
3. reconstruct the CLB and test it in cooperation with other interested countries 1975-1978.

International Law Applicable to Deep Sea Mining:
Existing Rules of International Law and Arguments

With regard to existing rules, the threshold question is, What area constitutes the "deep seabed"?

In doing so the Continental Shelf Convention was proposed. Under this act, coastal states have exclusive exploration and exploitation rights over natural resources of adjacent submarine areas.

These area rights extend out to the 200-meter isobath or beyond that, to where the depth of the superadjacent waters admit exploitation.

Another argument that came up was, do the rules of international law apply to this area beyond national jurisdiction, which we shall call the "deep seabed"?

In general, the Convention on the High-Seas, which is generally declaratory of established principles of international law, confers rights and imposes duties on high-sea users. The foremost rule is that no nation may assume sovereignty over high-sea area.

Specific freedoms such as navigation, fishing, laying of submarine cables and pipelines and "others which are recognized by the general principles of international law", are provided.

Another task that came up was what relevance is high-seas doctrine to nodules mining?

In brief, it means that until accepted rules emerge governing the miner's activities, he has an international obligation to pay "reasonable regard" to other high-sea users, including navigators and fishermen.

Some nations have recently assented that the deep seabed area and its resources are common property of mankind. The United States has consistently rejected that contention.

Under high-seas customary law, the deep seabed area cannot be seized as national territory. But from that a major question has evolved. Who has title to the manganese nodules resources?

To answer that question it would be impossible to define but so far those having the technological capability to exploit the resources might find it in their interest to maintain that the nodules belong to the first possesser.

All one could say at this point is that existing high-seas doctrine would permit some protection of one's rights to exercise high-seas freedom. Also reasonable criteria would have to be marked against specific facts and the International law does not provide the minor or his banker with the type of security such that of land mining.

United Nations Deep Seabed Committee on Prospective Issues in Legal Regime

In 1970, the United States put forward the first detailed and comprehensive proposal for a regime which would apply to the mining of manganese nodules in the area beyond national jurisdiction. This was the beginning of the United States Draft Convention on the International Seabed Area.

In the U.S. Draft, an "International Seabed Resource Authority" would have the power to license the mining of manganese nodules and would carry on certain supervisory activities in connection therewith.

Essential to the U.S. Proposal are the international standards to protect the ocean from pollution, to protect the integrity of investment and to prevent unreasonable interference with other uses for the ocean. In addition, the United States strongly supports sharing revenues for international community purposes and compulsory settlement of desputes.

Several important issues have emerged. One primary question is who would control an international authority?

Obviously, the well accepted principle of sovereign equality in U.N. affairs implies that each nation is entitled to be treated as a sovereign.

The United States has proposed a governing counsel composition and voting structure for its proposed International Seabed Resource Agency which would accommodate both the one-nation - one-vote principle and the legitimate concerns and expectations of those nations having the greatest responsibilities for mining the nodules. Other nations have put forth proposals, and more can be anticipated in the negotiations before this question is finally settled at the Law of the Sea Conference.

One other issue of concern is prospective world supply and demand for extracted metals.

The most relevant document regarding prospective international law concerning deep seabed manganese nodules is the Declaration of Principles adopted by the U.N. General Assembly in December 1970. These principles will provide the starting point for the multilateral treaty terms on the deep seabed to be negotiated at the Law of the Sea Conference.

The principles provide that the area beyond national jurisdiction shall not be subject to appropriations, and that no state shall claim or exercise sovereignty or sovereign rights over any part of it. The principles go on to state that no claims or rights may be acquired with respect to the area (and these are key words) or its resources, incompatible with the international regime to be established.

A LOOK AT MANGANESE

by Rene M. Tanaka, Hilo High School

INTRODUCTION

Manganese nodules discovered by Gahn in 1774, can be found on the Pacific Ocean Floor. These nodules containing elements that could help the United States become richer and help by providing jobs, have not yet been mined. Though some people have been thinking about mining these nodules they have not done so yet.

In this report, I shall give a brief discription of the manganese nodules, why they should mine them, its effect on the United States and Hawaii.

I have chosen to write my paper on manganese nodules because I feel that I should do some research on them because of the elements that could bring alot of money to the U.S. Also the ways it could help the economy of the U.S.

Methods of Research

My method of research is of books and newspaper article. I went to the library for most of the books but the rest I borrowed from the marine science teacher. The newspaper article was taken out of the Honolulu Advertiser.

Mananese nodules can be found on the ocean floor of the Pacific growing on rocks and shells. They contain many elements such as nickel and cobalt which is imported by the United States. Mining these nodules could save alot of money for the United States.

Although along the Hawaiian Island there is alot of manganese nodules the richest contrates of manganese is located in an area along the equitorial belt of the Pacific.

John Mero of the University of California has estimated in 1962 that there are 1.6×10^{12} metric tons of these manganese in the ocean floor. He also believed that the nodules could be sold at a profit of $20 a ton. Which would amount to over one billion dollars.

The manganese nodules will grow in areas which have a low sedimentation rate or where there are strong currents that prevant other sediments from settling. The melting point of the manganese is 1260° C. and the boiling point is 1900° C. The atomic weight is 54.9380 and the atomic number is 25.

Manganese nodules in the Pacific have not yet been mined and processed to be sold to other countries. If the United States could mine them we would save alot of money because we wouldn't have to import any more nickel and cobalt. We could even make a profit if we sell some to the other countries. In mining it more jobs will be available for the unemployed. But unfortunately the area of rich contrates of manganese is beyon the two hundred mile zone.

In order to mine these nodules the company needs a processing plant and the nearest land that can supply their needs in building the plant. Hawaii is the land that is able to supply their needs.

Having the mining plant in Hawaii will help the unemployment rate from increasing. Mining them in Hawaii will make the cost of copper, sodium and the rest of the elements cheaper for the residents of Hawaii to buy then if it were processed in the mainland. There are alot of advantages of having the plant in Hawaii but we must also look at the disadvantages. Such as if the plant should pollute the beautiful shore water to process the manganese. Or it might cause some other problems. Before we do agree on allowing a company to build a plant here in Hawaii we should look at the pros and cons very carefully or we could make a big mistale.

If a company does process these manganese nodules how will they do it? I think that they should melt the nodules and extract the nickel and cobalt. Or they could grind the nodules and extract the elements they want.

Mining the manganese could effect the economy of the United States. It could also help in the progressing world of today.

CONCLUSION

In conclusion I would like to say that manganese will surely effect Hawaii some how. And we must not make a wrong decision. For I feel that if we allow the company to build their plant here we will be the ones who will either be lucky or suffer what it does to Hawaii.

B I B L I O G R A P H Y

Goldenpaul, Dan Information Please Almanac, 1973 p. 438

Gross, Grant M., Oceanography, 1976 p. 128

Engel, leonard, and editors of Time-Life books, The Sea, 1961 p. 173

Honolulu Advertiser ,

Hawaii told it must hurry to share in seabed riches Feb. 16, 1977

MARINE RESOURCES: PROBLEMS AND REASONS FOR MINING MANGANESE

by Jan K. Miyashiro, Kailua High School

Abstract

Presented here in this paper are debatable issues concerning the development of manganese from the bottom of the ocean. Five resources were used to obtain information on the problems and potentials in the mining of manganese. Problems discussed have to do with the effects on the marine environment mining may have, economical, legal, political, and technological feasibility.

Introduction

Manganese nodules are shaped like lumpy potatoes and are approximately five centimeters in diameter. There are many theories as to how manganese nodules are formed. Two such theories are: 1) Many scientists assume that manganese and iron particles precipitate out from seawater, and accumulate particles to make the precipitates heavy enough to sink. Once on the ocean floor, the nodule, rich in, and with a great variety of minerals, does not stop enlarging in size. It continues to collect mineral runoff from land or material from undersea volcanoes. 2) Other scientists believe that natural catalysts separate and concentrate minerals to form nodules. Most of the time, the minerals form around a small, hard peice of matter, like a stone or piece of bone.

These nodules were discovered by the HMS Challenger, during a three-year expedition lasting from 1873-1876. The nodules are found in the Atlantic, Pacific, and Indian Oceans, but are most abundant in the Pacific. Nodules tend to form far beyond the continental shelf, at a depth of about 4 to 5 kilometers.

Manganese nodules contain approximately thirty different minerals,but interests have been centered on only six: copper, nickel, cobalt, manganese, aluminum, and zirconium. Because these metals have a great role in everyday American life and in technological material, there has been a growing interest in the nodules. However, the nodules are not easy to obtain.

The problem is that by mining on the sea-floor, the balance in the ocean environment could be thrown off. Other obstacles in the way of development are economical, political, technological (methods of obtaining), and legal considerations. If we are not careful in exploiting the ocean's resources, dependent marine life will suffer and die, and the ocean will be in a terrible plight. The ocean must be studied so that we can take resources without harming it. For economical reasons, a use for all or most of the nodule should be found before it is exploited; this is sensible since the cost of exploitation will be so high. There will be more industrial product per nodule for the money's worth.

Body

Technology presents a problem bacause many methods used in mining may be economically unfeasible, or damaging to the environment. Here are two examples of technology and the problems they may cause. These methods may be used in the future: 1) The "continuous-line-bucket system" is a procedure in which a bucket, attached to a cable, is let down to take some nodules. The bucket is then pulled up to the mining ship. 2) The easier method to use is hydraulic. A long pipe, connected to a dredge head will be towed behind the mining ship and dragged along the seabed. Pumps will be used to suck up the nodules and bring them to the ship.

First of all, the problem with both methods, or with any method is that we do not know enough about the ocean to be sure we will not harm it by mining for the nodules. If we do not know how the ocean will be effected, we should not tamper with it until we know more about it. There may be vital nutrients, food, minerals and other materials that take part in balancing the ocean environment.

As Soucie (source of information) says, if the bucket system is used, sediment will constantly be falling on nutrients vital to benthos. (Benthos are animals that live on the ocean floor. They feed on algae and other marine life that live on the bottom of the ocean. As the bucket is pulled up to the ship, this food is buried.)

As a result, the benthic creatures will starve, if not be buried, and animals feeding chiefly on these creatures will also starve, thus disrupting the food chain.

In fact, both methods will in some way stir up minerals and particles causing not only problems in the food chain, but turbidity around the mines as well, Soucie says. Alien minerals from the ocean floor will be brought to surface waters and may cause disturbances to life there.

This means that the concentration of minerals in surface waters may be high too suddenly to support life. (Most sealife cannot stand sudden changes in their environment.) Eventually, if enough minerals are dissolved in the water, eutrophication may result. (eutrophic--rich in dissolved nutrients, but lacking enough oxygen to support life.) If more salt gets stirred up and dissolved, many creatures who cannot adapt to slight changes in salinity will perish. Because of the turbidity of the water, sunlight will not penetrate well, and plant life cannot use the sun to help them produce food (through the process of photosynthesis). Since plant life is the first step of any food chain, animals as well as plants will perish.

Soucie comments that when the water is turbid, animals will make an effort to move out, and others will avoid coming in.

This is because turbid waters block the sunlight, which prevents plants from getting their food, which in turn prevents animals from getting their food.

Another piece of equipment that may have an adverse effect on the ocean's sealife is the drill, or some other heavy piece of equipment. When these heavy pieces of equipment are dropped to the ocean floor, benthic creatures could be crushed easily, cutting down their population, and creating problems for animals that feed off the benthos.

Besides causing an unbalance problem in the ocean, the discharge from the mining ships will cause water pollution. Processing the minerals will produce pollution, and wastes left from the nodules after processing. On the average, refining factories will throw out 90% of the nodule as waste. Some factories are planning to process copper and nickel which makes up 2-3% of the nodule. So far, only one company is planning to process manganese as well as copper and nickel.

On the average, nodules contain about 24% manganese, 1% nickel, 1% copper, and 2% cobalt. These percentages may not look too high, but compared to their percentages in material found on land (ores), they are very high. In the Pacific, there are 1 1/3 times as many reserves of copper as on land, 10 times as many reserves of manganese, and 13 times as many reserves of nickel. It costs a company more to mine a mineral with a smaller percentage of it; this is why we are so interested in the manganese nodules as a resource.

Doctor John Mero, who wrote Mineral Resources of the Sea, takes special interest in manganese nodules because they are so mineral-rich and abundant. He predicts that there is enough zirconium, copper, manganese, aluminum and cobalt to last man for thousands of years. If we started producing these minerals, we would be able to produce more than we need.

We can now see the value of the nodules, and also some problems of getting them. They are so far down from the ocean surface, and about 65 kilometers out at sea.

Location of the nodules will bring up a legal and political problem. Countries will debate over rights to areas containing manganese nodules. Those with long coastal areas will fight for possession of goods within a designated coastal zone, and those with short coastlines, no coastline at all, or with poor mineral content offshore will fight for something-like sharing minerals found anywhere in the ocean. There will be much international competition for the goods, and much negotiation on laws of ocean mining.

Once political and legal problems are out of the way, the nodules will probably be exploited despite harm it may do to the ocean. Industries will rush at the chance to get a profit and the best deals on the resource. Edward Wenk (source of information) feels that: "Unless rational alternatives among competing uses are evaluated, the trend will continue to be toward single-purpose uses, motivated by short-term advantages to individuals, industry or local governments. Such exploitation may actually dissipate resources. . . Each single-purpose use may seem justifiable on its own, but the overall effect of piecemeal development can be chaos."[1]

In order to prevent some environmental harm and to learn more about the ocean, experiments on mining should be carried out on a mini scale environment. Researchers could prepare a defined medium (environment in which all components are known), in which would be placed all of the elements and forms of life in the area to be mined. Mining at the rate that the real environment will be mined at, and providing all operations and problems that could be caused will be introduced to this man-made environment. All of the seasons of the year will have time to occur so that the sealife may have time to follow through with their natural lifecycle and migration habits. Enough time will be given so that these life forms will react fully to the mining situation. Because researchers will be working in a defined medium, they can find out exactly what is affected in the area.

Conclusion

Mining areas should be studied more thoroughly before they are touched, so as not to harm the inhabitants. If we mine without greed for our own profit by coming upon an international agreement, our precious resource will not disappear so fast. There will be a smaller chance of harming the environment since less of our resource will be used, and at a slower rate.

Footnotes

[1]Edward Wenk, "The Physical Resources of the Ocean," Scientific American magazine, September 1969, p. 354.

REFERENCES (OR SELECTED BIBLIOGRAPHY)

Kovalik, Vladimir. 1966. THE OCEAN WORLD. New York: Holiday House.

Loftas, Tony. 1970. THE LAST RESOURCE. Chicago: Henry Regnery Company.

McKee, Alexander. 1969. FARMING THE SEA. New York: Thomas Y. Crowell Co.

Soucie, Gary. 1976. "Mining the abyss: treasures, troubles." Audubon 78 (6): 122-128.

Wenk, Edward Jr. 1969. "The Physical Resources Of The Ocean." Scientific American: 347-355.

The Seabed Controversy of the Third United Nations Conference on the Law of the Seas: Who Shall Possess the Great Wealth Beneath the Sea?

Jo L. Whitman
University Laboratory School

Abstract

A major decision that must be reached before the Third United Nations Conference on the Law of the Seas can progress is the degree to which the doctrine of common heritage should predominate. This is important because until this point is established the developed nations and the underdeveloped countries will not compromise on other points.

One of the things expected to come out of this conference is an international treaty, perhaps establishing an International Seabed Resources Authority which would regulate exploration and exploitation of the marine resources beyond the areas of national jurisdiction.

No fair or equitable agreement can possibly be reached at the Law of the Seas conference unless all nations of the world are willing to compromise in negotiations for the treaty.

The Seabed Controversy of the Third United Nations Conference on the Law of the Seas: Who Shall Possess the Great Wealth Beneath the Sea?

In 1967 Arvid Pardo, the Ambassador of Malta, suggested to the general assembly of the United Nations that the seabed resources located beyond the areas of national jurisdiction be declared the "common heritage" of all mankind. In 1969 a resolution was passed by the general assembly, indicating the general acceptance of this new principle by the nations of the world.[1] At the same time the United Nations created a subcommittee for the purposes of studying a possible regime for the peaceful uses of the ocean's resources. The work of this committee and a general international concern eventually led to the convocation of the Third United Nations Conference on the Law of the Seas in late 1973. This conference has been ongoing for several years, but its progress is questionable. It remains to be determined whether the marine resources will be allocated and the profits distributed under res nullius, res communis, or common heritage.

One of the major purposes of the Third United Nations Conference on the Law of the Seas is to establish an International Seabed Resources Authority (ISRA). The major issue currently inhibiting the progress of this Conference concerns the functions of the ISRA. While all countries have generally agreed upon the need for an ISRA, they have not arrived at an agreement on the specific functions such an international organization would perform. The developed countries desire a "weak" ISRA, which would merely act as a registration agency, granting licenses to mine for a set amount of royalties. The less developed countries prefer a "strong" ISRA, which would issue contracts to mine, have the power to revoke the contracts, enforce regulations, and

1- resolution 2574 of the twenty-fourth session of the general assembly control both the processing and sales of seabed minerals.

The positions taken by the developed and underdeveloped countries, for a "weak" and "strong" ISRA, are related to two larger perspectives in international politics: the realist and idealist viewpoints. These views, in their extremity, do not appear to be compatible with arriving at an international treaty for the oceans. There is, however, room for a "middle" or compromise position between the realist-developed countries' position and the idealist-underdeveloped countries' position.

The idealists tend to view the Third United Nations Conference on the Law of the Seas as an opportunity to further the "common interests" of all nations through the creation of a new international organization. The existance of the "common interests" of peace, order, equity, etc., for all nations is the fundamental idea essential to understanding their actions. The underdeveloped countries, the poor and the weak, tend to favor these principles. On the other hand, the realists tend to consider the conference as a conglomeration of tentative compromises, each country pursuing its own national interests, and that there are no basic common interests. These principles are prefered by the rich, powerful countries which have high levels of technology.

Background: The Ocean Setting

In the past the sea has been used as a medium for transportation and a source of food, but the seabed has gone unused and unclaimed by man because of its inaccessability. The developed countries today may have the technology to recover the resources of the seabed. In the Law of the Seas debates it is the minerals of the seabed that are currently of importance, especially manganese nodules for their cobalt, nickel, copper, and manganese. Now that these resources are technologically within man's grasp, mankind must decide how to allocate the resources and distribute the benefits. The traditional concepts of res nullius and res communis, under which a resource was either claimed as the exclusive property of a nation (res nullius), or left as the property of whomever went out to get it (res communis), do not seem useful principles under present circumstances.

The principle of res communis means that a few of the wealthiest, most developed nations would be free to use large quantities of marine resources, as there is an uneven distribution of capital and technology in the international system. This would have the result that there would be little or no resources for the less developed countries, those without the technology or capital to exploit the resources now. Res nullius, on the other hand, would involve dividing the seabed into zones of national jurisdiction. This would cause a different set of problems, such as disputes over pollution controls, the right of free passage, and the laying of communication cables. Res nullius would also encourage military use of the seabed by the developed nations and the placement of detection devices or nuclear warheads on or under the seabed as the ocean space would be "owned" by the nation, meaning that it could be used in any way seen fit by the government of the country.

Ownership of the deep seabed resources is a particularly sensitive issue because most of the marine mineral resources such as manganese nodules, containing precious minerals, are outside the areas of national sovereignty, beyond even the proposed 200 mile economic zone, where ownership and exploitation rights are as yet undecided.

Profit Distribution and the ISRA

The "common heritage" idea proposed by Arvid Pardo is very different from past international and national policies in that the technologically advanced countries would not receive most of the profits from deep seabed mining. Common heritage advocates mining by the wealthy nations and pooling the profits to help the underdeveloped countries. Profits would be distributed very differently under res communis and res nullius. Under res communis the developed countries would be doing the mining and taking home their profits, and under res nullius the developed countries would again be doing most of the mining and taking part of everyone's shares home. The developed countries would also choose the best mining areas, especially the mineral rich area in the Pacific basin, the one best known for such a high mineral concentration in the nodules. The realists of the developed nations (DC) prefer either res nullius or res communis to common heritage, saying that it is not fair for them to do most of the investing and have the underdeveloped countries (UDC) share the profits as provided under the common heritage idea.

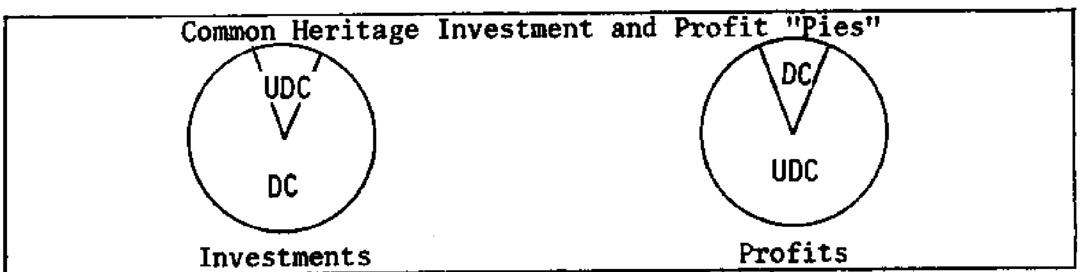


figure 1

Idealists in the developed nations view common heritage as a means of helping the underdeveloped countries advance technologically and economically. The realists view this as unfair because the two "pies" do not have the same proportions.

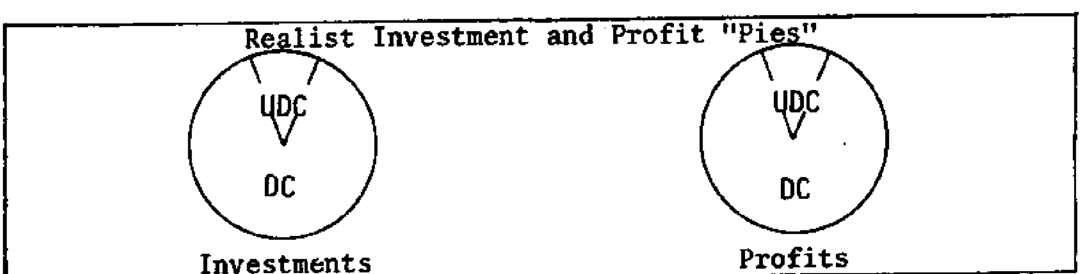


figure 2

The size of the two sectors of the profit "pies" is undefined in either case. Financial information on deep seabed mining is insecure, as actual mining has not yet been done in commercial proportions. Profit estimates are even less accurate because of more variables (i.e. processing costs, possible "royalty" fees, transportation costs, etc.) in the computation of the economic costs/benefits. This lack of accurate information and vagueness on the proportions of the actual profit "pies" has created some difficulties for those trying to negotiate a compromise between the developed countries' and the underdeveloped countries' positions on an ISRA. Some people argue that the ambiguity on the size of the "pies" is a major cause of the deadlocked debates on the seabed authority. A better case probably could be made for the assertion that it is the conflict between the developed countries' desire for a "weak" ISRA and the underdeveloped countries' preference for a "strong" authority (each with their own plan for the distribution of benefits) that has been the most decisive factor in influencing the present deadlock.

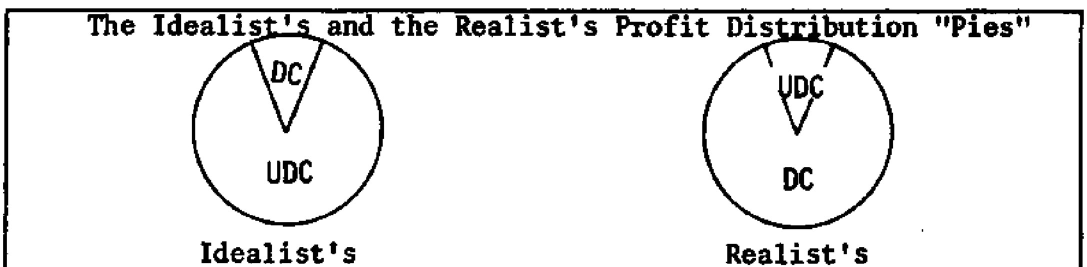


figure 3

The 'distribution of profit' "pies" shown in figure 3 are not the same. The circle on the left shows basically how the idealists think the profits should be distributed. The vision of the idealist is captured in four major principles. These goals, as stated by Professor George Kent, include:

1. Peacefulness- The resource should be used only for peaceful purposes.
2. Equity- The benefits derived from the use of the resources should be distributed equitably. This in turn means that...
   2a. As a common heritage, everyone is entitled to share in some measure in the benefits from the use of the resource. This necessarily implies non-appropriability, such that no individual, corporation or government has

the right to claim the resources for its own exclusive benefit.

2b. A greater share of the benefits should go to the poor.

3. Environmental Integrity- As the heritage of the future as well as the present, users of the resource should show respect for the environment, limiting both depletion and pollution.
4. Common Management- To give effect to these principles, a governing agency responsible for their implementation must be established. That agency, acting in behalf of all mankind, should provide for participation by all affected parties in the making of its decisions.[2]

In relation to the ocean, these principles imply that the ocean should only be used for peaceful purposes, and that all nations should get a portion of the profits from the use of the marine resources. The disadvantaged should get a greater share, plus conservation controls should be effective in preserving the resources for future generations. Management should be by an international authority concerned for all nations. The single most important dispute at the Law of the Seas Conference is whether or not the poor nations should receive most of the profits from the use of marine resources, and if so, how and in what proportions.

The right side of figure 3 deals with the more conservative view of the realists, who view everything from the frame of reference that each nation wants to increase its own benefits at the expense of all others, and work with only self(national)-interests in mind. The developed countries who generally go along with this philosophy seem to act on the basis of only short term self-interests. They argue that the two sides of figure 3 are unequal in that the underdeveloped countries should not profit from all the investments and effort the developed nations put into the utilization of marine resources. If the experimental mining done this year by Deep Sea Ventures and other corporations from the United States, Japan and West Germany prove profitable, then these nations may become even more adamant on obtaining exclusive rights to areas of the seabed, especially the known areas of high mineral concentration in the nodules.

2- Kent, George. 1975. "The Common Heritage Idea" third draft, page 4.

The following table[3] shows how the developed countries and the underdeveloped countries view the ISRA.

	Issue	The "weak" ISRA: Developed Countries	The "strong" ISRA: Underdeveloped Countries
1.	Who shall be allowed to exploit the seabed resources	any "responsible" state or corporation should be granted a contract to mine. amount of royalties specified in contracts.	only ISRA may mine. ISRA should have a monopoly, control of sale of products, and distribute revenues.
2.	How much power given to ISRA	little or no discretion or flexibility. Equal (favorable) treatment for all. everything written into the treaty.	ISRA acts as an autonomous international organization. has flexibility and discretion, few or no restrictions.
3.	How much ISRA control of access and rate of development of marine resources	unlimited access, countries can take whatever they wish.	ISRA given authority to refuse or grant access and to determine rate of development.
4.	How should operating decisions be made	should be a council, which requires affirmative vote plus majority of six most developed nations.	major power in ISRA assembly.
5.	How do underdeveloped countries participate in deep sea mining	by participating in mining operations (borrowing capital and technology from other nations).	through ISRA: equal participation in management. UDC's representatives would take part in operations (mining and refining) to gain knowledge.
6.	How are interests of land-based producers of minerals to be protected	monetary compensation from the international fund.	effective production and price controls.
7.	How can the security of marine mining companies be assured	should be written into treaties and contracts.	ISRA can change contract terms.
8.	How much of profits should go to the ISRA	fee for grant, royalties on production in contract	all profits to ISRA.
9.	How will ISRA adapt to changing conditions	treaty specific, no provisions for change.	ISRA should have plenty of discretion, treaty flexible

A compromise on these points could be negotiated along the following lines. The ISRA should be given control over who may mine the ocean's resources, with 'when', 'where', and 'how much' specified in the contract. These should be negotiable, though the ISRA could refuse to grant the contract. These contracts should allow the use of the area specified in the contract for, say, five years, with revision dates specified in the contract. This means that before each of the

3- Ocean Education Project. An International Seabed Resources Authority and Deep Seabed Mining, Draft on.

revision dates (perhaps every 12-18 months, specified in treaty) both the mining company and the ISRA must renegotiate the percentage of profits that go to the ISRA, the amount that may be mined, or any other details specified in the treaty.

If anything in the contract, including environmental restictions, quantity controls or revision dates are violated, the ISRA should have the power to revoke the contract. The ISRA should have the flexibility and discretion to refuse access to resources, and to limit the rate of development.

Mining companies would apply for contracts, submitting complete work plans with the application. Two or more areas should be applied for. If the contract is granted, the company must then pay a fee proportional to the size, and concentration of minerals in the area contracted to be mined. The companies must also submit financial reports along with the royalty payments stated in the contract. Nations may examine the ISRA's file of plans.

The treaty should be the guidelines for the ISRA, containing basic conditions for operations (rules of the road), a lower limit on the percentage of profits to go to the ISRA, and provisions for amendments.

Compromises by the two positions are currently non-existant, even though each of the points cited in the table has a wide range of middle ground that could be utilized. In determining the amount of authority that the ISRA should have, each specific question should be carefully, yet quickly examined, with the possibility of compromise kept in mind by the people negotiating each position. If there is no compromise in the near future, the nations which have the technology to mine will either go out and utilize the resources under res communis or claim them under res nullius and then use them. The United States' experimental mining in the Pacific is one step toward all nations making claims to the ocean resources in the near future. Once either res communis or res nullius is established it will be much more difficult to replace it with an international authority. Without both the developed countries and the underdeveloped countries participating in an international treaty the economic gap between the rich and the poor will increase. This in turn will increase political tension, making negotiations of all kinds more difficult.

Conclusion

The Third United Nations Conference on the Law of the Seas seems to be deadlocked. Some agreement must be reached soon, before the developed countries begin to mine the manganese nodules on a large scale. Once the nodules are gone they are gone forever for all practical purposes. The regeneration rate of the nodules is so unknown that it cannot presently be considered in our thinking on the problem. Mining nodules under res communis would make the establishment of an ISRA more difficult. Once the developed countries and the underdeveloped countries have both decided to compromise, much ground is left between the two positions, and the details of the treaty could then be worked out. The main controversy is which concept will predominate: res nullius, res communis, or common heritage. I feel that both res nullius and res communis are heavily slanted in favor of the few economically and technologically developed nations with extensive access to the sea. Common heritage is the fairest of the three in that the benefits from the use of the marine resources are distributed to more nations, thereby furthering the economic differences less than either res nullius or res communis. The poor nations and the wealthy nations will need to seriously consider compromise strategies in order to bridge the differences that may arise, inhibiting the effective implementation of common heritage.

Jo L. Whitman
University Laboratory School
March 1977

SELECTED BIBLIOGRAPHY

Borgese, Elizabeth Mann, ed. 1972. Pacem in Maribus. New York, NY: Donn, Mead, and Company.

Friedmann, Wolfgang. 1971. The Future of the Oceans. New York, NY: George Braziller.

Padelford, Norman J. 1970. Public Policy for the Seas. Cambridge, MA: The MIT Press.

Gerstlē, Margaret L. A New Regime for the Oceans: Background on Existing Law of the Sea and the Seabed. Ocean Education Project, 245 Second Street, N.E., Washington D.C. 20002.

Benson, Bruce. 16 February 1977. "Hawaii told it must hurry to share in seabed riches" Honolulu Advertiser pp A-1, A-4.

Ocean Education Project. An International Seabed Resources Authority and Deep Seabed Mining, Draft on: 245 Second Street, N.E., Washington D.C. 20002.

Ocean Education Project. Looking Back to Geneva: Looking Ahead to New York. 245 Second Street, N.E., Washington D.C. 20002.

Ocean Education Project. The Oceans: Deciding for Future Generations. 245 Second Street, N.E., Washington D.C. 20002.

Kent, George. 1975. "The Common Heritage Idea" Third draft.

Kent,George. 1974. "Ocean Development or People Development?".

Kent, George. 1975. "The Third United Nations Conference on the Law of the Sea: What Happened in Geneva".

Acknowledgements

I wish to thank Dr. John P. Craven, former Marine Affairs Coordinater for the State of Hawaii, present Dean of Marine Programs at the University of Hawaii, and Director of the Law of the Seas Institute at the University of Hawaii, for information and references. I also wish to thank Laura G. Carmona, Jean N. Chatani, Cheryl U. Harstad, Faith G. Paul, James P. Schoenberg, Olive B. Schoenberg, D.W. Whitman, and Nancy C. Whitman for their helpful review of this paper. Special thanks to John P. Craven, Norman H. Okamura, and Douglas K. Pendleton for sparking my imagination with a lively discussion.

COASTAL ZONE MANAGEMENT

THE KAIMU PROBLEMS

by Betty Tampon and Venus Hauanio, Pahoa High School

EARTHQUAKES AND RELATED EVENTS OF HAWAII, NOVEMBER 29, 1975: A PRELIMINARY REPORT....

There has been a great many earthquakes these past years, ans as you may remember the biggest one of all recently was in November 29, 1975, at 0048. The earthquake had been centered about 5 Km beneath the Kalapana area on the southern coast. It was said that before the great earthquake there had been numerous foreshocks which followd a 5.7-magnitude jolt at 0036 that same morning. But the terrible thing was the tsunami that had followdd. That tsunami waves had reached a peak of 12.2-14.6m above sea level. Then when the earthquake in 1975, caused Kalapana to sink it made people think that these events serve as a critial, though tragic, reminder that nature in its own way is saying to be careful and is always constantly reminding us that the never ending ground movements are there. Kalapana has undergone many centuries of slowly but never ending sinking. Scientist say that Kalapana shall sink and that the entire island is slowly sinking. The earthquake that shook the Big Island in 1975 was so strong that it had been felt by the neighbors Islands of Maui and on Oahu, more than 400 Km from the epicenter. During that earthquake and after intense bursts, glows, or flashes of white to bluish lights lasting from a few seconds to about minute, were observed by many people. Including a few of the Halape campers which had been traped in the tsunami after the earthquakes. This earthquake caused alot of the subsidence of South coast. At Kalapana there had been a Lagoon in the area betw en Hakuumapoint that had been muddy or even dry during low tide. Now is filled with water and good for swimming. Kalapana and Harry K. Brown Park are flooded during high tide and looks like high tide at low tide. A portion of Kaimu Black Sand Beach, 1 KM northeast of Kalapana wave swash noe enters the coconut grove fringing the beach, which the waves are killing the roots of the coconut trees.

KAIMU SLOWLY SINKING INTO SEA...

The Kaimu Beach was once a beautiful smooth bàack and beach extending far out, which unfortunately is covered consid rably by the ocean waves now. It is true that the sea is eroding the black sand off Kaimu beach, but that is not the whole truth. Kalapana has been sinking for many years. Which has been causing the vanishing sands and wave washed palms. Kalapana has been sinking at least two inches a year, and at times it has sunk considerably more. But the greastest had been in 1924 when the eruption of Halemaumau caused Kaimu to drop 14 ft. The person who kept careful observation was the late Orin C. Wilson. There also had be n another earthquake on November 29, 1975, that once again caused Kaimu to sink. The November 29, earthquake really did it tò Kalapana this time. During high tide the waves would cover the road. This also changed Kaimu's ocean currents. Now the wave washes away the sand instead of washimg the sand to the nearby area by Kaimu. The county council thought that building a break water the erosion of the sand would stop. Henry Kawaihae thought that the county would be wasting money there would be more earthquakes and the break water could not stop the Kalapana area from sinking which is enevitiable. No-one knows if Kaimu will be there for ever or how long will we have our beautiful black sand beach. But while we have it, our publicspirited people and organizations have put out an effort to improve our reecreation areas. Building a break water would have been costly and a temporary measur for it is very likely that the land will continue to sink and the black sand will be washed away by the never ending waves.

METHODS OF PROFILE GRAPHS...........

Exact locations of profiles were determined during survey of Kaimu beach on 3 July of 1975. Each of these profile locations was then fixed by means of marking coconut trees two meters above the sand level at berm level. (At times we would go down to Kaimu to check conditions of the beach). At this time July 1975 the berm was well beyond the reach of waves.

There are a toyal of four profile locations; Since Kaimu beach is in essence, two beaches seperated by a headland, the distance and the distincprofiles are not indicative of one long expanse of beach surface, rather two profile locations were fixed on each beach. For exact locations of profiles refer to figure 2.

From July to November a total of nine days were spent obtaining profiles are graphed in figure 3, The dates of profile taken are color-coded for easy references;

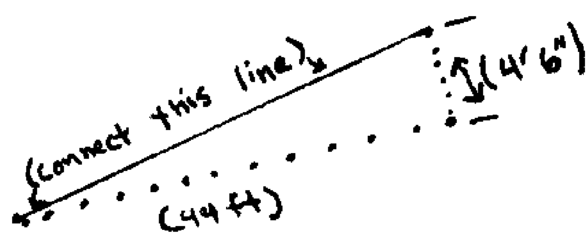
3 July..........Pink
Jul 17..............Green
Jul31,.............Violet
Aug 14..............Blue
Sep 30..............orange
Nov22..............black

All dates 1975 circles in profile lines on the graph are points where measurements were taken along the surface Vt beach.


Pink
Violet
Green
Blue
Orange
Black
MEASURMENTS IN FEET
15
10
5

TO GRAPH PROFILES:

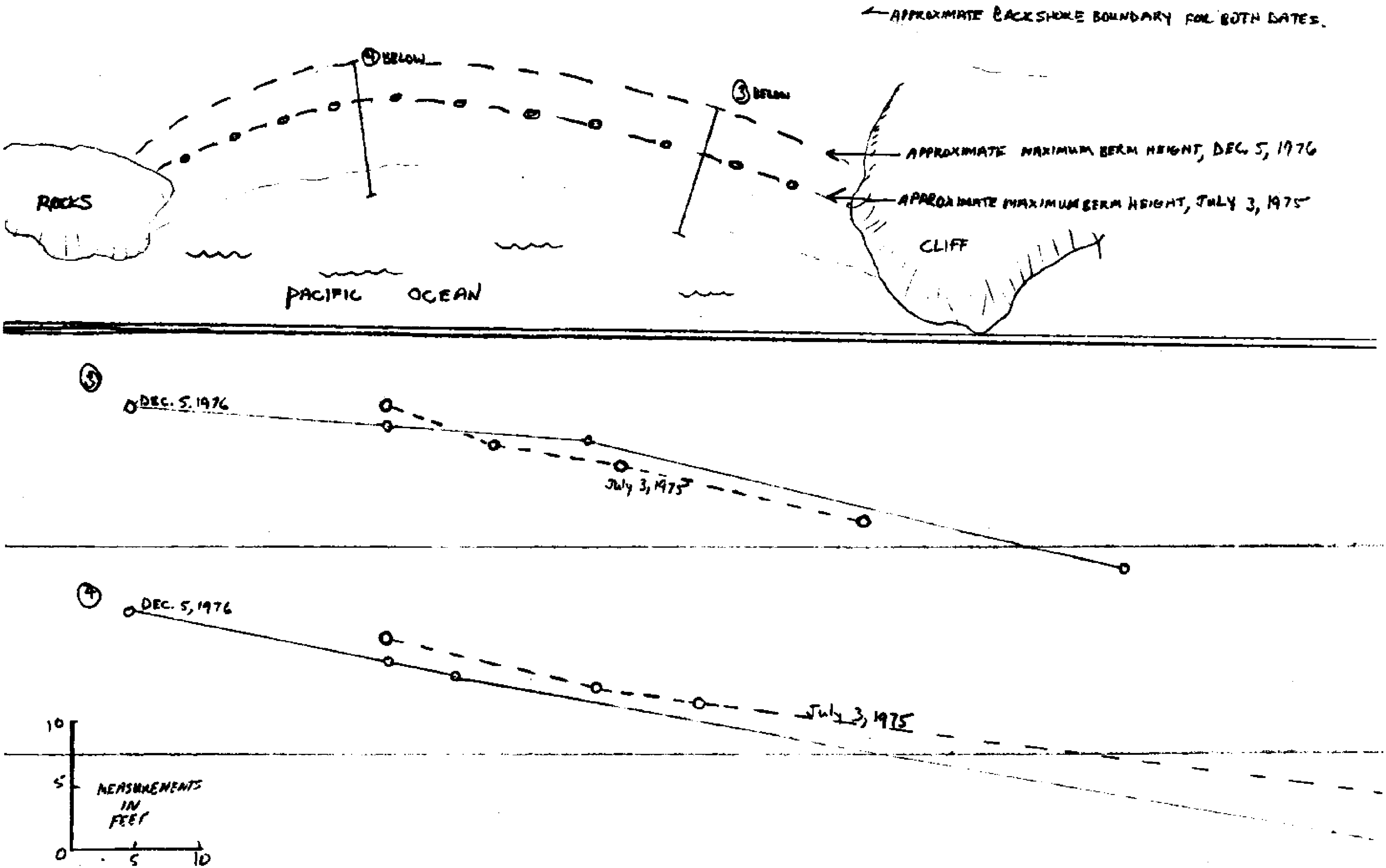
First change meters (on distance measurements) to feet. A calculator is handy for this. Use graph paper with six squares to the inch. Scale should be about 1 inch equals 10 feet. (This way the graphed profiles profiles will fit on 8 inch 11 inch paper). Begin at left hand margin and start with shore measurement. Example: It is 14.7 meters from backshore to crest of berms in #3 and its rises 4 feet 6 inches. Convert 14.7 meters to feet measure the distance off on your graph paper, using the scale you have decided on. Then measure 4 feet, 6 inches up (vertically) from that point and connect the top point with your beginning point.



This will give you the slppe of the beach. Continue like this until profile is completed. You should come out with a diagram as the above.
The December 5, 1976, beach profile is drown out in detail on the following pages. One site from each of the two beaches at Kaimu is used.

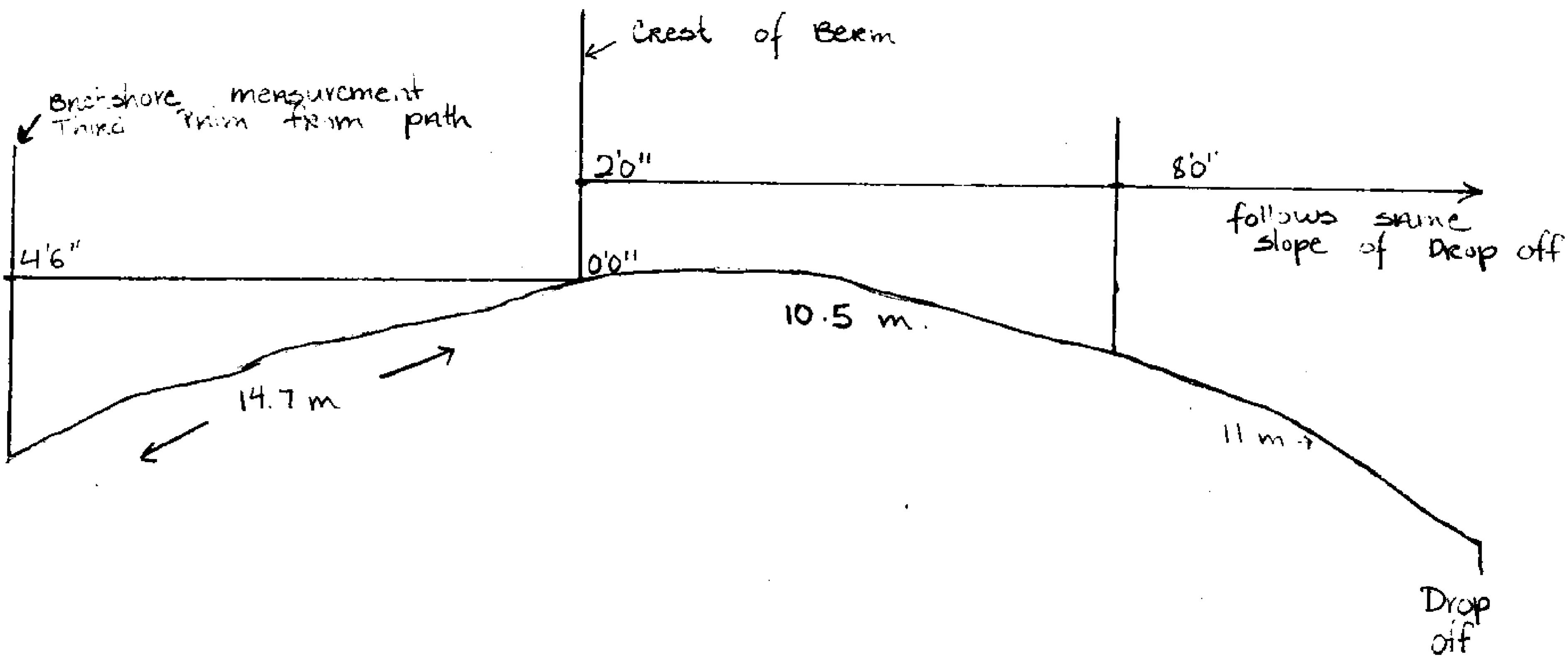
COMPARISON OF BEACH PROFILES, KAIMU BAY, HAWAII

JULY 3, 1975
and
December 5, 1976

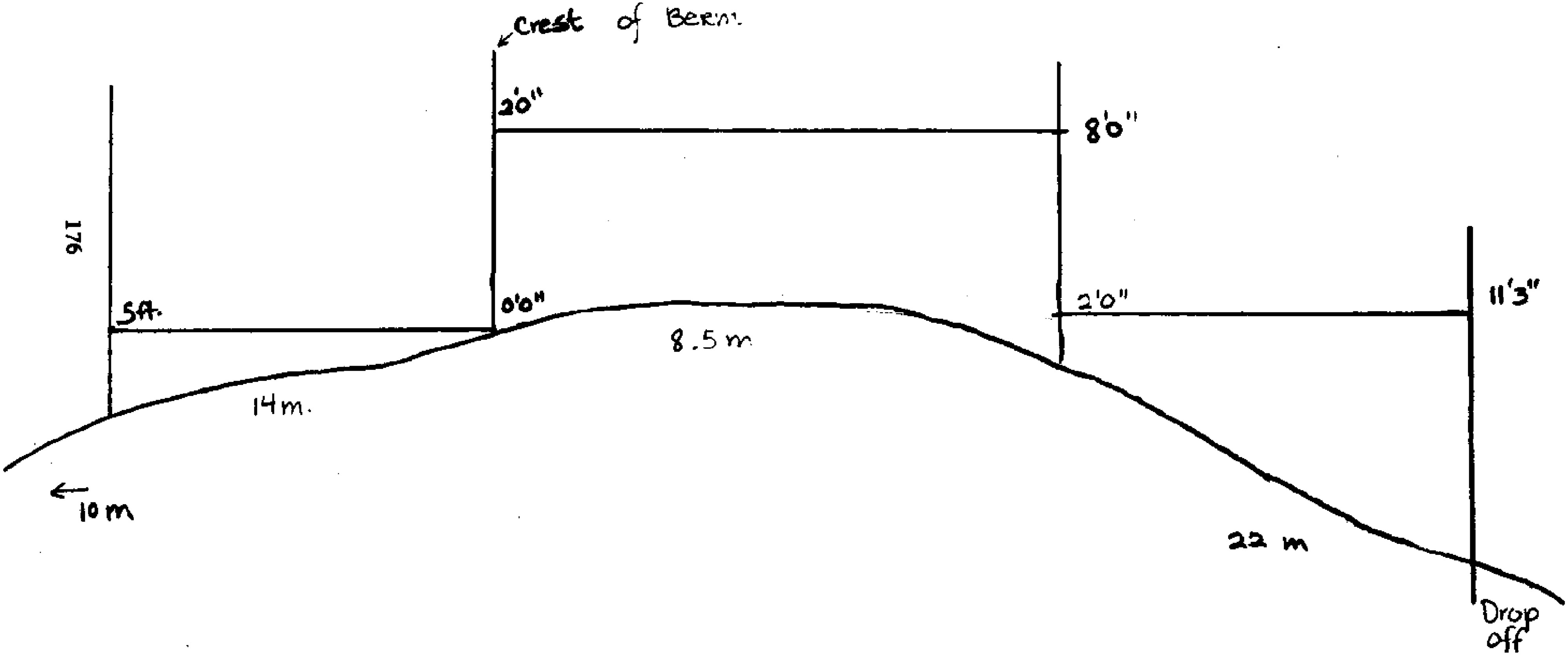


#3
December 5, 1976
After the Earthquake

High Tide   Waves 2-3 ft.



#4
December 5, 1976
After the Earthqake



PROPOSED KAIMU BEACH EROSION CONTROL PLAN

The United States Army Corps of Engineers has proposed an erosion control plan for the Big Island famous Kaimu Black Sand Beach at Kalapana, Puna.

A 1,350 foot long submerged breakwater across the bay would lie constructed and a 100,000 square feet of dry beach area would be developed. The County, in the meantime, is acquiring the lots behind the beach for expansion of the park. Due to the slope of the land, the type of sand at Kaimu, and the volcanic activity, any measure taken at Kaimu by county of Federal agencies would only be of temporary mature.

It is our feeling that only such measure would be a waste of public funds.

BIBLIOGRAPHY

1). Baldwin, Helen- Kaimu Beach Sinking into Sea

2). Sketch by Corps of engineers- Proposed Kaimu Beach Erosion

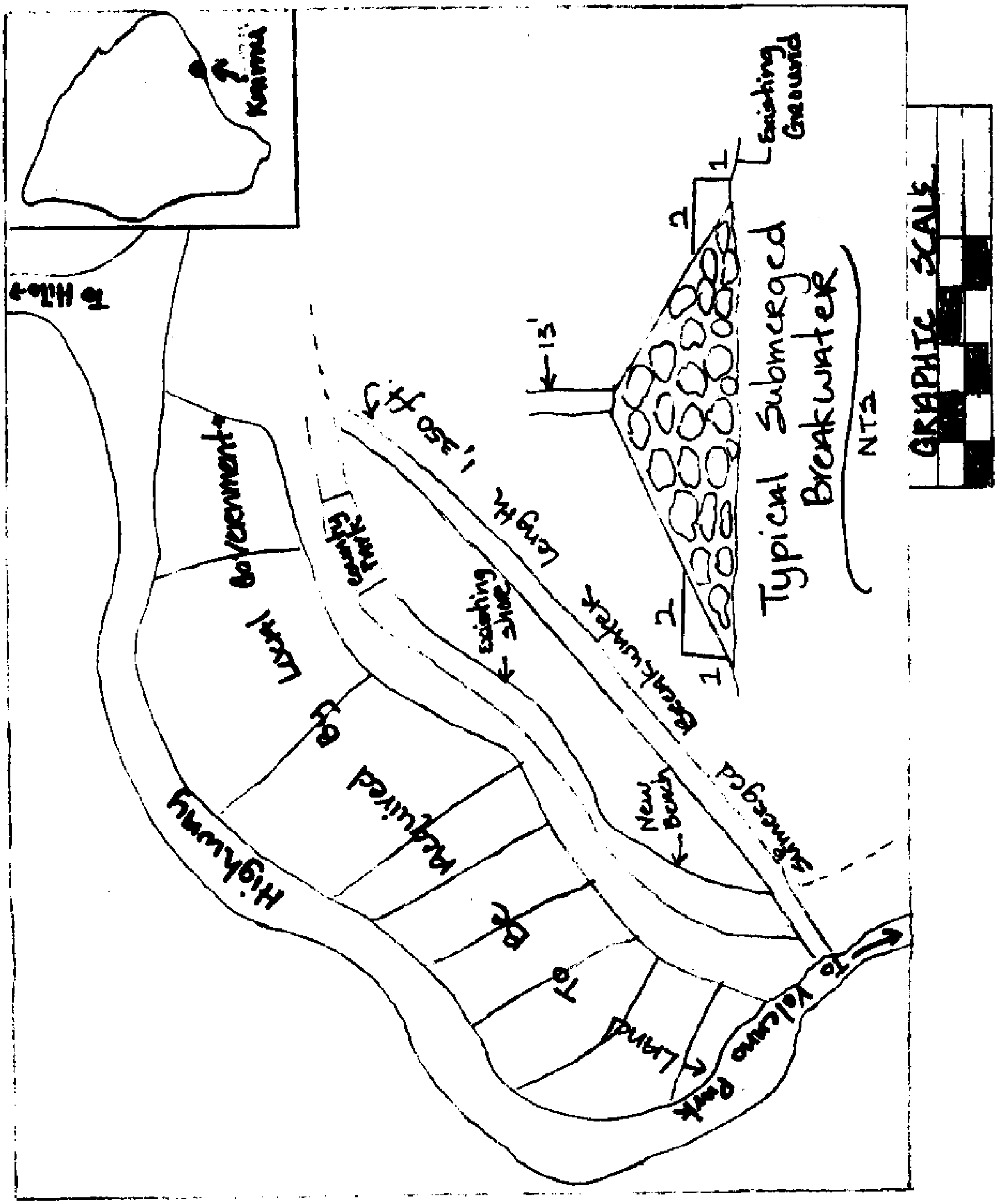
3). Benneman, Larry- Kalapana is still sinking.

4), Rood, Jim- Kalapana Sinking slowly down

5). Benneman, Larry- Kalapana Coastline is Sinking

6). Omeara, Patrick- Research on Kaimu Project - Helped Graph

7). Library Public Pahoa- Newspaper Articles.



Kaimu
To Hilo
Highway
Land To Be Acquired By Local Government
County Park
Existing Shore
New Beach
Submerged Breakwater Length 1,350 ft
To Volcano Park
13'
2
1
2
1
Existing Ground
Typical Submerged Breakwater
NTS
GRAPHIC SCALE

OIL POLLUTION IN THE OCEAN

by Andrew B. Simson, University Laboratory High School

ABSTRACT

Large quantities of oil is being lost every week as a result of oil spills. Oil tanker accidents are responsible for the largest proportion of the loss. These accidents are due to poor navigation, poor construction of the ships, mechanical ~~fixtures~~ failures, and poor maneuverability. The resulting loss of oil is serious because we need all of the oil we can get and because of the environmental problems which result, especially harm and loss of life to birds, fish, mammals, and other sea life. In addition, coastal lands are damaged, ruining recreation areas, and causing economic loss to businessmen. The solution to this problem is a more concerned citizenry demanding laws regulating ship building, number of ships in an area, and strict regulation of oil rigs.

INTRODUCTION

In this paper, I am going to discuss the frequency of oil spills, particularly from tanker accidents, the causes of those spills, environmental, social, and economic effects and the need for legislation to prevent further oil spills.

PROCEDURE

I surveyed major books, magazine articles, and newspaper stories for current discussion of this problem. My paper presents a summary of the major issues and recommends a solution.

OIL POLLUTION IN THE OCEAN

Late on the night of August 9, 1974, a two hundred thousand ton oil tanker known as the Metula, was making her way through the Strait of Magellan headed for the Chilean coast. She carried one hundred and ninety four thousand tons of Arabian crude oil. She was making nearly her full speed of fourteen and a half knots. She rode the back of the flood tide. With all this momentum, she ran herself on a high shoal known as Satellite Patch. All at once, thousands of tons of oil began pouring out of her hull causing a huge oil slick.

If Metula had gone aground off some densely populated area there would have been all kinds of environmental fuss about it, but since it happened away from the general public, it did not get the notoriety it deserved. She deserved a lot of notoriety because when she (the Metula) finished spilling, she had spilled fifty three thousand five hundred tons of oil into the sea.

Scientists that were hired by the oil company said, "There was not much damage done." This is hardly the case. The U.S. Coast Guard made a search of the entire area and found that much environmental damage was done. For instance, there are many penguin nesting grounds on the coast of the Strait of Magellan. Hundreds of them were found dead, soaked in oil, not to mention the flying birds, fish, and other marine organisms either killed or damaged by the oil.[1]

Another example of oil spills caused by oil tankers was the Toy Canyon. On March 18, 1967, she became one of the more than 250 ships to get stranded off the Skilly Isles. On a clear day just before eight o'clock, she drove herself at full speed of seventeen knots onto Polor Sock, largest of seven shoals in that area. Before all the law suits and complaints were over, a number of seldom used words such as, "environment" and "pollution" were used.

This is the first time that people could see the environment destroyed before their very eyes, because 80-88% of the water bird population was destroyed in that area. The kinds of birds to feel the largest impact were the Auks, Vaser bills, Puffins, and Chiefysgullsenots. Over 10,000 birds were found dead on or near the Skilly Isles. Tory Canyon lost her whole cargo, about twice what Metula had, this making her the largest and most destructive oil spill in the history ofman.[2]

On March 3, 1968, the Ocean Eagle, an 18,250 ton oil tanker grounded in San Juan Harbor, Puerto Rico. Then she broke in two and spilled the entire load of oil into the sea. The fact that American beaches and shores are so close to Puerto Rican shores made this disaster big and immediate. So now the people of America were crying those unfamiliar words, environment and ecology, too. The American people were showing that they not only care about their living space as a tool to better their own lives, but also as a resource to hand to future generations reasonably intact.[3]

Six point one million tons of oil are spilled into the oceans of the world each year. Of this two point one million tons are from oil tankers. The other four million tons come from other sources such as off-shore drilling, run-off, or just plain dumping.[4] As to dumping, two hundred thousand tons of oil are dumped each year when the tanks are being cleaned; they simply fill the oil tanks with salt water, wait until the oil comes to the top and dump it back into the sea.[5]

Another way oil spills occur is by off-shore oil drilling. On Tuesday, January 18, 1969, in Santa Barbara channel an oil rig well, number 21 had a blow-out and a massive mixture of oil and natural gas came pouring up the drill pipe. Then another oil well on the same platform blew up while the drill bit was being extracted. A concerned group of citizens of Santa Barbara had tried to stop the drilling in order to preserve the channel's scenic beauty and what they were certain was a threat to the environment. They protested that the channel bottom was unstable and earthquake prone and that the oil had been coming up naturally for so long that early mariners had used the oil slicks as navigational aids. But no one listened and look what happened, the most devastating oil pollution problem in American history. "Drilling in Santa Barbara channel was a goof," said one of the founders, Alvan C. Wengand.[6] Oil companies spent millions of dollars to clean up beaches, birds, and water, but these disasters dramatize man's increasing abuse of the sea.[7]

More oil spills are occurring every year due to cheap building of the ship's structure and engines and the fact that maneuverability is so poor.[9] The hulls of the largest ships are a mere 35 mm thick. Not only is it easy for the hulls to crack when hit on rocks, but when there is a storm the pressure is so great that the hulls crack by themselves. Super tankers are the largest moving things that man has ever built or probably ever will. The maneuverability of these largest of ships is very poor causing many collisions. A 200,000 ton tanker when fully loaded takes more than twenty-two minutes or a distance of three miles to stop.

Most oil tankers' engines are steam engines, with a single boiler and a single propeller; this type of engine is used instead of the regular diesel engine because they are less expensive to buy and easier to automate, which means there are less crew members to pay. The major reasons oil tankers get stranded is that their engines break down. Such was the case for a fully loaded 40,000 ton tanker, the Simfonia, who lost steam six miles off Danger Point near Cape Aguthas. She was at the same spot where another tanker, the Warfa, had gone aground just six months earlier. This meant that if the Simfonia were to go aground too, the water birds, penguins, and seal population would have to suffer the killing effects of oil within just six months, not giving them enough time to recuperate.

Flooded engine rooms are the main cause for engine breakdown. According to the Tanker Advisory Center in New York seven tankers suffered from engine room flooding in 1974 and even more do now. Another cause for engine breakdown is believed to be the variations set up by the long hulls and the fact that oscillations can cause severe overstress and cause the injector pipe to rupture.[10]

Very little is known about the long term effects that oil has on the sea. The short term effects are: it kills living organisms, it hurts businesses, fishing industries, hotels, and sport fishing, and it destroys the livelihoods of many people who depend on the sea as a source of food. All crude oil is poisonous and the sea can take just so much poison before it dies. The sea is by no means a delicate structure but, nothing lasts forever. The sea can biochemically absorb some oil but it is not known how much oil. Some scientists say that the sea will keep on absorbing the oil without it making any difference and then some say that this is false and that the sea can't take any more and that if we continue to pour oil into the ocean it will die never to recover?

When an oil tanker spills in the middle of the ocean somewhere, it appears that after it is cleaned up that there was no damage done, this is false. Little living organisms known as phyto and zooplankton are killed when they hit the oil slick. Many kinds of fish and sea mammals eat these small plants and animals who either die or pass it on to their offspring which might be caught by fishermen. This is one reason there is an increasing amount of mercury in the fish we eat. Phytoplankton makes up a large portion of the oxygen we need to breathe.[8]

When an oil tanker spills oil, there are many ways to clean it up, but the newest and most effective was recently tested by the Coast Guard. They use a cutter, a helicopter, a floating barrier (the high seas state oil containment system) and a pump. A 126,000 gallon recovery barge is used to hold the oil after it is pumped up. The way the system works is the barrier surrounds the oil and the pump sucks it up and pumps it into the barge. The helicopter is used to carry the equipment to the spill. The new way eliminates the problem of what to do with the absorbent material after they have sopped up the oil. This system is now being used to clean up a 7.6 million gallon spill off Nantucket Island.[11]

The solution to the problem of oil spills lies in legislation. Laws must be made to preserve our coastal zones. In particular law restricting the number of ships in one area, because collisions are a big cause for oil spills. Laws should be passed on how ships should be built, because they are very poorly built considering the dangerous cargo they carry. Coastal zoning must be strict, because off-shore drilling causes spills that are often unnoticed. Many people are unconcerned until the oil affects their lives. They should become concerned before it affects them.

FOOTNOTES

[1]Noel Mostert, "The Age of the Oil Berg," Auto Bon, Vol. 77, No. 13, May 1975, pp. 18-47.

[2]Jeffery Potter, Disaster by Oil, (New York, New York: Macmillan Company, 1973) pp. 1-42.

[3]Jeffery Potter, Disaster by Oil, (New York, New York: Macmillan Company, 1973) pp. 44-65.

[4]Noel Mostert, "The Age of the Oil Berg," Auto Bon, Vol. 77, No. 13, May 1975, pp. 18-47.

[5]Noel Mostert, "The Age of the Oil Berg," Auto Bon, Vol. 77, No. 13, May 1975, pp. 18-47.

[6]Jeffery Potter, Disaster by Oil, (New York, New York: Macmillan Company, 1973) pp. 153-165.

[7]Noel Mostert, "The Age of the Oil Berg," Auto Bon, Vol. 77, No. 13, May 1975, pp. 18-47.

[8]Noel Mostert, "The Age of the Oil Berg," Auto Bon, Vol. 77, No. 13, May 1975, pp. 18-47.

[9]Noel Mostert, "Super Ship," (New York, New York: Warner Communications Company, 1975) p. 193.

[10]Noel Mostert, "Super Ship," (New York, New York: Warner Communications Company, 1975) p. 193.

[11]R. Norman Malheny, How the Coast Guard Mops Up Oil, Christian Science Monitor, January 14, 1977, pp. 18-19.

COASTAL ZONE MANAGEMENT: WHO SHOULD MANAGE AND WHY

by Susan M. Anthony, Campbell High School

INTRODUCTION

Coastal zone management is one of the problems facing hawaii seeing as we have a lot of land in the coastal zones. I feel that the people should have the right to say what happens to our shores. Personally I feel that most of it should be preserved for the public as parks and recreation areas. I don't think that hotels should be able to section off a part of the beach for visitors only. I also have a stand on the buildings that are along the coast, I feel that they should be limited to only 2 stories because they ruin the sight of our islands they destroy the landscape and view of the natural Hawaii.

In the past the residents of the islands have not been asked as to how they feel the coast lines should look. I also feel that this is an injustice to the residents of the coastal lands, because they don't have a say in what is happening to their land.

I feel the poteintial for the coast lines is a very different and unusual thing for the future I feel that the coast can be developed into an area of great importance in the future. The coast lines contain such things as beaches, corals, precious corals, sands, and many of our reef fishes and animals etc. Which may be essential to our life in the future.

My reasons for research are that I feel the coastal areas are indeed imprtant and I wanted to find out more about them so I could understand the reasons for decisions made regarding them. Also I am quite disgusted with some of the decisions that have been made and want to know why such things were so important and why.

The issues which face Hawaii today have alot to do with the coast and it potential for the future also it's recources that we can use now. One of the issues today is one of the height restrictions of buildings, another is who should use the beaches and who should decide what to do with them. A problem which I feel is nessessary to solve is one of shuld hotels have the right to section off a part of the beach for it's customers.

Who should say what is done with the beaches, I say its the people. The ultimate power rests with the people.

METHODS OF RESEARCH

I asked several people what they thought of the problem of coastal zone management, how they felt about it, what was wrong, and how it could be improved. Also who they think should decide what is to be done with the coast lines.

I also went to the library and found articles in the newspaper about how many of the decisions were made and who made them. I also found out about groups such as Life of the Land and what stands they had in such matters also what they did about the decisions that they didn't like,sometimes the decisions were reversed because the peopke stood up for what they believed in. I reasearch how the people could go about changing some of the decisions that they feel are unfair or just wrong. Most of my work is on how I feel and on the opinions of other people who live on the shores and who use them for surfing, sailing, swimming etc. I got some of my ideas about how people could change deci sions already made form the constitution of the United States also by talking to social studies teachers etc.

RESULTS OF RESEARCH

I have found that many people think that they should have the right to say what happens to the places they live on use. Many don't know that they can change decisions that have already been made. Many don't realize what is happening to the environment around them. Take the case of Kahe beach park. It was decided to build an outlet to the electric plant waste off shore, the people didn't know anything about it by the time the found out construction had alrealy started. The surfers and Life of the Land fought against it and a n alternative was found so that they didn't have to ruin the surfing area. I found that the people have rights which allow them to protest any decisions they feel are worng 1) the right to protest 2) the right to public assembly 3) the right to freedom of the press 4) the right to freedom of speach etc. These things can help people voice their opinions if they feel they are right and are willing to follow through with their protests. There are other things which people can do to try an reverse a decision they can write the person who made the decision and find out their reasons, also to tell them how they feel about it.

Many of the newspaper articles that I have found have said how people have changed certain decisions. Some of the articles stated that there was no public resistance because the public did not know what was going on. I think the government should make it a point to let the public know what is happening tho the land the live on.

Groups such as Life of the Land are for the people they help the people in and with any fight to get what they want done with the land they live on or use. They use certain tactics which make known their views and use legal help to change anything they feed is wrong. Most of the people who use the for recreational purposes agree that our coastal areas are being managed unfairly and that they could fingure out better ways of doing things. Not nessessarily reversing the decision but changing the way of doing it to benefit the people. One person suggested that within one half mile of the beaches be left for buildings only two stories high. Also that hotels not be given permission to fence off the beaches but leave them open to the public. Another opinion that I got was that the " government has no right to tell us what to do ", this opinion I feel is very strong but essentially right. The rest of the opinions that I got favored the people having a say in what is done with the coastal zone.

CONCLUSIONS AND RECOMMENDATIONS

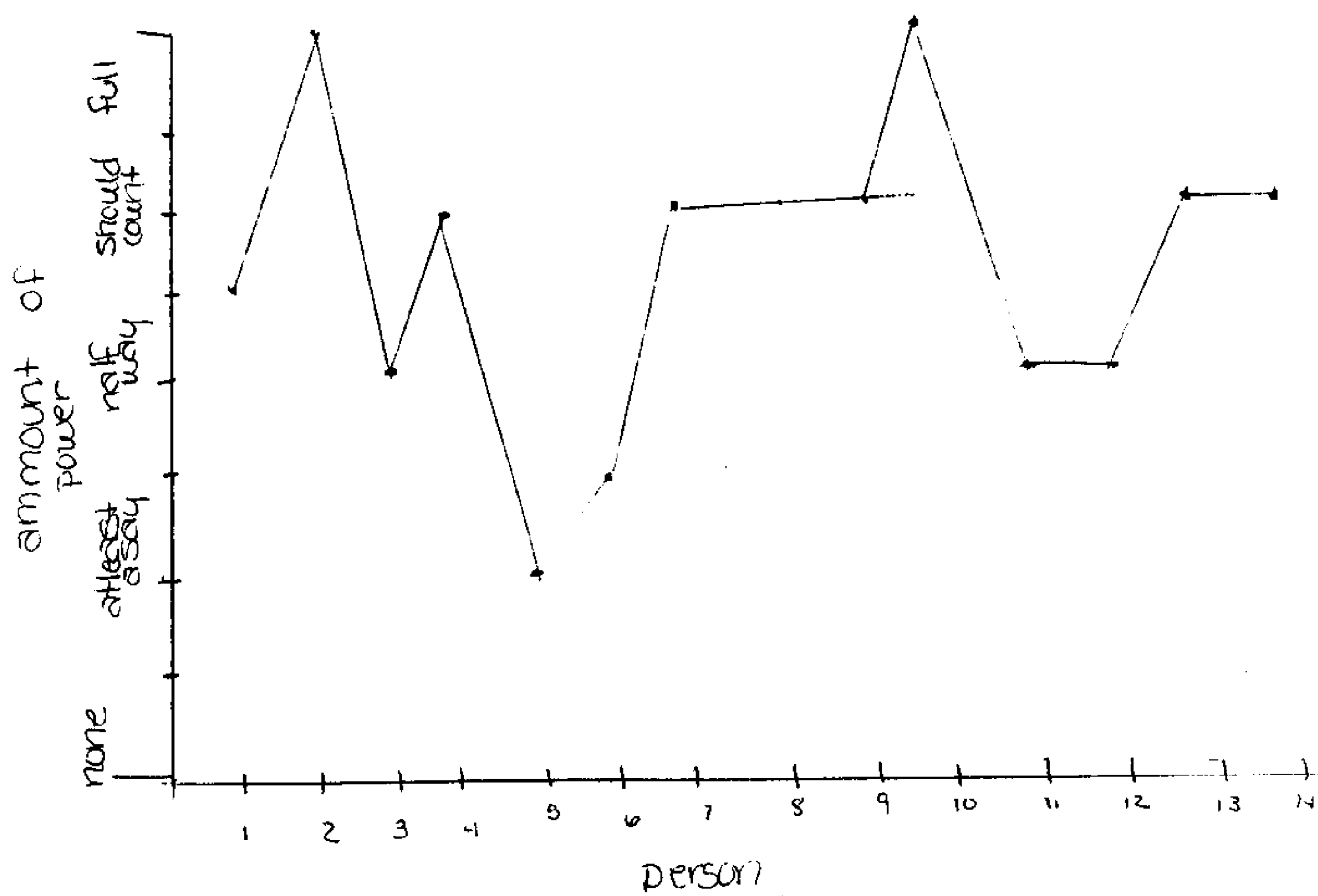
I have come to the conclusion that the people feel that they should have a say in what goes on but just don't know how to go about doing it. I have also come to the conclusion that many people are unhappy with the way things are being done and want to make a few changes. I feel that the way we manage our coastal zones will determine our future and the recources that we come up with for the near future. or example we could grow algae in the areas where nothing elase seems to be doing good, we could then use the algae for fertilizer, food, etc. That is one alternative to the problem of what to do with land (ocean) that cannot support much life.

Another conclusion that I have come up with is that the people who are deciding what is to be done with the coastal zone don't care what the public feels about this problem and that they'ed just as soon take the cheapest way out and that they feel our rights are unimportant.

I feel that the people should have the right to mangae or at least have a say in the manabgement of the coastal zones because that is the only way to bring about a change and to insure a democracy in the way we do things in our island life. Also because if the people didn't have say they would feel planned upon. They would feel as if their rights and what they think was unimportant.

I feel we should let the public have a say in the future of our coastal zones because it is their future too and we need their opinions to help balance things out so they weren't so one sided.

Below is a graph of how much power the people think that they should have, I think it will help to illustrate my point.



SHORELINE PROTECTION: WHERE DO WE GO NOW?

by Robert P. Mumford, University Laboratory High School

INTRODUCTION

Coastal Zone Management, hereafter referred to as CZM, in this paper represents the laws and guidelines set forth to preserve our coastal areas and where possible improve these areas for the enhancement of scenic, aesthetic and recreational uses, and to enhance the wildlife in these said areas.

As is plainly visible in the southern portion of Kaneohe Bay on the windward side of Oahu, poor management and bad planning in development has had a very real and harmful effect on both the coastal and marine resources, biologically, economically and sociologically. In 1969 a study was conducted of the coral in Kaneohe Bay and the results were shocking. In the southern portion of the bay, the area where the highest rate of development took place, ALL of the coral was dead.

This one study alone proved quite vividly that before development, or any alterations to the ecosystem takes place, it is imperative that planning for the effect on the shore and marine environment take place. Without adequate management and enforcement of such laws, wide spread distruction will take place in our island chain.

This paper will deal with the present Shoreline Protection Act and find out if it really is effective in its present state. If not, the big question is: where do we go now?

The present Shoreline Protection Act was enacted in 1975 as a direct spinoff from the U.S. Coastal Zone Management Act. This Act was enacted into law in 1972 as a measure designed to protect the coastal areas of the United States. It offered to any state that was interested in planning for coastal zone protection, program development grants, large amounts of monies to be used for consultants and planners to do surveys and plan for coastal zone management.

Through these Federal grants the Hawaii Shoreline Protection Act came about. Its goal was to "preserve, protect and where possible, to restore the natural resources of the Coastal Zone of Hawaii." The Shoreline Protection Act of the Legislature of the State of Hawaii states that any development should provide "Adequate access...to publicly owned or used beaches, recreational areas and natural reserves to the extent consistent with sound conservation principles." And that "adequate and properly located...wildlife preserves are reserved. Provisions are made for solid and liquid waste treatment...which will minimize adverse effects upon the special management area resources." And finally, "Alterations to existing land forms and vegetation except crops, and construction of structures shall cause minimum effect to water resources and scenic and recreational amenities and minimize danger of floods, landslides, erosion, siltation or failure in the event of earthquake." Also, in relation to the water quality and life in the sea, it stipulates that "the Authority shall seek to minimize, where reasonable...any development which would adversely effect water quality and existing areas of open water free of visible structures."

As a result of this Act boundaries were set up by each individual county for their own coastal areas. These zones had to be filed with the State by December 1, 1975. With this deadline in mind the zones were rather hurriedly

The question now to answer is: are these boundaries effective to uphold the standards set up in the Shoreline Protection Act?

To answer this question we need to first identify the detrimental effects and their causes that we need to protect against.

First, let's consider the natural causes of pollution and hazards to the shoreline:

1) Rainfall and Run-off Hazards

In the Islands the Hydrological Cycle is very important to our fresh water supply. This is highly evident on the Windward side of the islands. Evaporated water in the air condenses quickly in the change of altitude caused by the wind currents moving in an upward direction due to the steep Pali cliffs. (Diagram 1) Because of this, there is a high rate of rainfall on the Windward side. With this high rate of rainfall comes a correspondingly high rate of fresh water run-off. This draining water has a stripping effect on the land causing topsoil to be carried off. This soil run-off is then transported to the large streams that empty into the oceans surrounding our coasts. As is evident in the southern portion of Kaneohe Bay, siltation, the soil run-off into the Bay, has a very definite effect on the coastal area and the Marine environment. Also, geological drags off the Ala Wai stream mouth and the Pearl Harbor, Keehi Lagoon area shows that siltation is effecting these waters also.

2) Currents and Wave Patterns

Again Kaneohe Bay is a prime example of currents and wave action not being considered. Low flushing rates and low circulation of the water causes siltation to become cumulative. Great quantities of soil and sediments "pile-up" on the ocean bed. This has an effect of smothering the coral or bottom plants in shallow waters and making a shifting base that new coral or plant life cannot attach to, and in deeper water it smothers the nutrient product of the sea bottom.

The building of groins and piers has a definite effect on the coastal area as is evident in Florida where competing hotels have built groins out into the ocean to trap sand and build up their beaches. However, this causes areas that are down current to be stripped of sand and a drastic increase of erosion in these down current areas is the result. (Diagram 2)

3) Nutrient Supply in the Water

When considering any effect on the coastal area it must be realized that there is a very fine balance in effect and that the addition of nutrients into the system does not necessarily enhance the marine environment. In an imbalanced system the "desired" marine creatures sometimes are unable to utilize these nutrients, but the "undesired" marine animals can use them and begin to tip the balance, upset the ecosystem and over run the area in great numbers. Therefore, we must consider what we introduce into the system. It must be realized that natural stream beds and flood plains, the area at the mouth of a stream, filter out a lot of the silt and soil in the river caused by run-off, and absorb, due to plant life in the stream and flood plain utilizing nutrients, the excess nutrients that would overload the ecosystem. So we must carefully consider how we change this balance.

Now let's consider some of man's introductions into this system:

1) Construction

Near shore construction has a very immediate and obvious effect on the coasts. As was pointed out in the CZM goals, it will try to "preserve, protect and where possible to restore the natural resources of the Coastal Zone..." Therefore, any construction on the shoreline would be a violation of this goal. If construction were to take place then protection must be implimented to prevent pollution of the Marine environment due to siltation from run-off and change in the land and features that would cause adverse effects to the Coastal area. Also, it should be mentioned that construction can have a detrimental effect on our aesthetic enjoyment of this area, which would violate another of the goals set up.

However, it should be realized that any change in the environment farther inshore could have an adverse effect on the Coastal area also. As was pointed out earlier, streams carry run-off from higher ground and construction away from the coast could still be detrimental to the coasts by causing increased run-off to be carried into the streams and thus to the shoreline.

Also, in a lot of cases alterations to stream beds must occur for them to have the load bearing capacity for greater run-off. This, as was stated earlier causes an increase in the nutrients and also an increase of fresh water input into the seas which causes salinity to drop and possibly make it impossible for some marine creatures and plants to habitate that area. All in all any construction has a possible effect on the marine environment which directly relates to the Coastal Zone.

2) Sewage

Sewage outfall is an important aspect to consider as it effects the nutrient input, water quality, clearness, salinity, temperature, and general acceptance by people for aesthetic reasons and enjoyment. Sewage treatment, if handled properly could be an asset to the marine environment. It could add to depleted nutrient supplies in the system and replace needed chemicals that the ecosystem needs. However, if mistreated it could be a very real threat to life in the sea and the coasts that it borders. Also, the way it is dumped is very important. Studies have indicated that deep sewage outfall has negligible effects on the marine environment and possibly even a significant positive effect on the ecosystems involved. Here again it is important to consider the currents and wave patterns of the area to decide the best possible choice of sewage outfall into our oceans.

3) Industrial Uses

Industrial use of the coastal zone must be considered a preblem that must be resolved. The use of the oceans as a cooling agent in power plants has an effect on the marine ecosystem as it raises the temperature of the water by eleven degrees before reintroducing it back into the system. Fish, being cold blooded, rely totally on the temperature of the surrounding water for survival; also, pollutants are introduced into the water by such use. Using stream or other ocean outfall for industrial useage can pollute or harm existing life.

Harvesting of corals and other semi-precious objects from the sea should be controlled as these are one-time resources which are unable to be replaced once gone.

Structures by industries in the marine environment need to be regulated closely. A recent example of this are the groins built along Waikiki Beach onOahu that caused a drastic change in the distribution of sand along the area and shifting of surfing spots due to changing sea beds. This contradicts the goals of "construction of structures shall cause minimum effect to water resources and scenic and recreational amenities..." in the CZM Act.

Now that we have identified some of the hazards to our Coastal Zone area let's find out how well our present Shoreline Protection Act is set up to handle these threats.

The present "Special Management Area," referred to as the SMA, is now defined as "the land extending not less than 100 yards inland from the shoreline..." This is the minimum acceptable distance, but in many cases this is all that is included in the SMA.

The SMA objectives are "the maintanance, restoration, and enhancement of the overall quality of the Coastal Zone environment, including, but not limited, to it's amenities and aesthetic values..." With this in mind, consider the fact that the Department of Planning and Economic Development has found that, "for many coastal resources and hazards, activities virtually anywhere on each island could cause such significant impact..." to increase hazards in the SMA.

Therefore, it is realized that the present SMA boundaries do not meet their objectives of protecting their regions. As an example of this, one of the goals in the Shoreline Protection Act was to minimize "any development which would adversely effect water quality, existing and potential fisheries, and fishing grounds, wildlife habitats..." But any development on the island will have an effect on the water quality and the coastal area due to the run-off of water which can be transported from high inland areas to the sea in a matter of hours.

Because of this fact it needs to be realized that anything that happens to the inland areas of our islands has a direct effect on the waters and shores around our islands.

As another example of this, let's take the example of the pineapple and sugar cane agricultural uses on the island of Oahu. Although the area is as far distant as 7 1/2 miles from the sea it still has a direct effect on the ecosystem and the coastal area. Some of the detrimental effects are run-off from the irrigation, irrigation tailwater, and also water from fields that are being harvested that goes into the streams and rivers to be dumped into the ocean. Other causes of pollution from this industry include milling of the sugar cane, cane washwater is produced that is laden with silt, ash, trash and mill washwater. This washwater contains fine particles of sugar cane that has a cutting effect on the corals and rocks of the sea bed creating a virtual desert under the sea devoid of life. This effect is very apparent off the island of Molokai. Also, harmful agricultural chemicals and risidual fertilizers are washed to the sea. The cumulative effect is a multipoint pollution center causing three points of pollution to be added to the ocean. (Diagram 3)

A good example to consider is the California Shoreling Act. It has its Special Management Area extend as far back as several hundred miles from the shoreline because of the effects that it could have on their coasts.

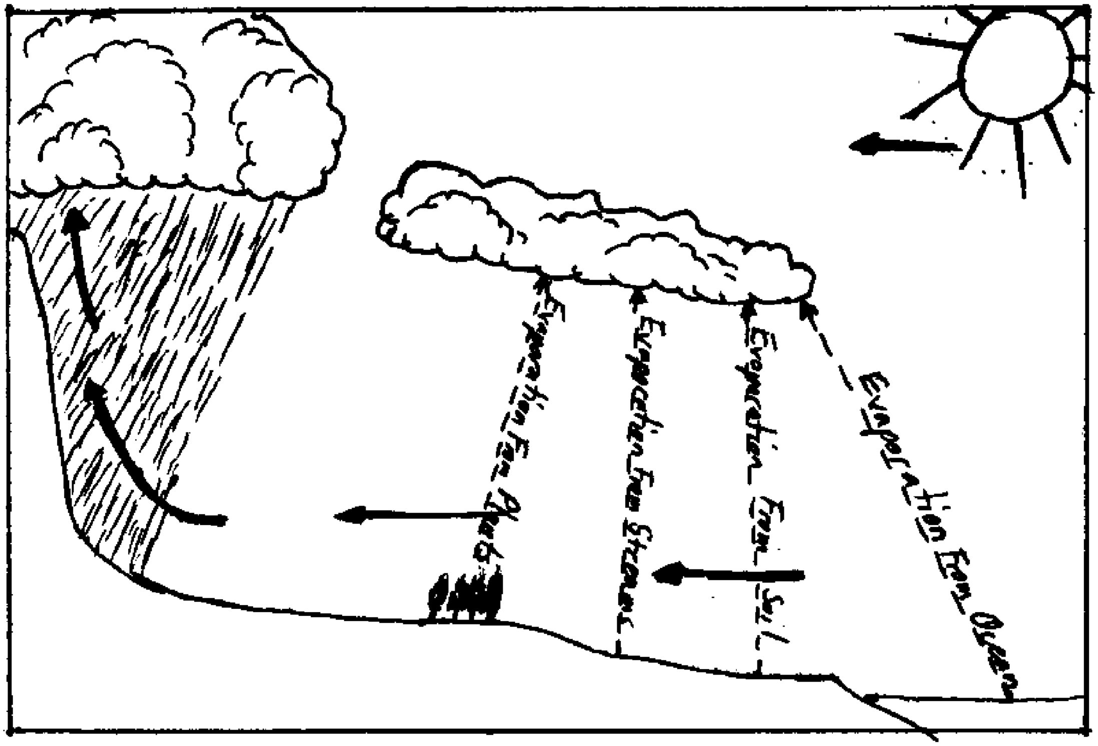


Diagram 1 Hydrological Cycle

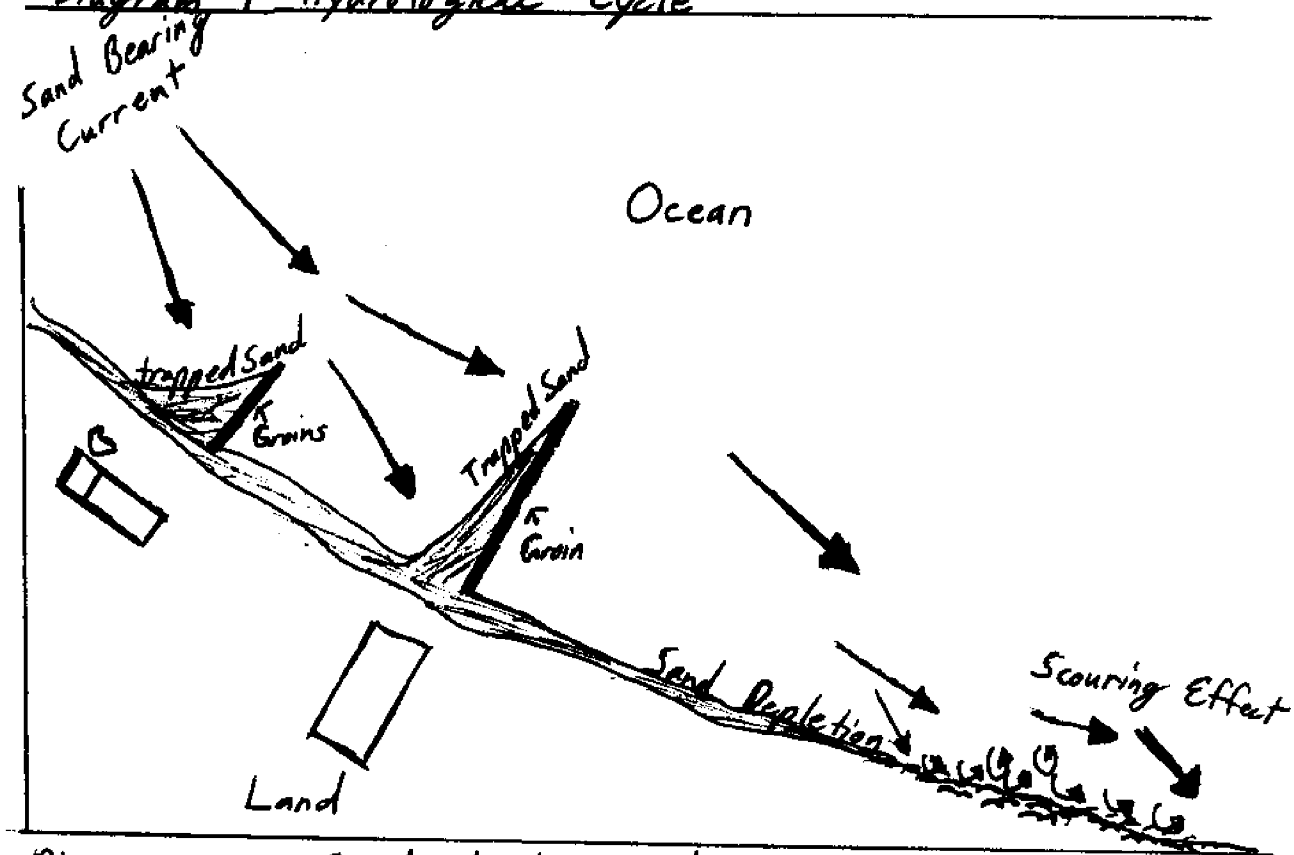


Diagram Sand depletion due to Groins

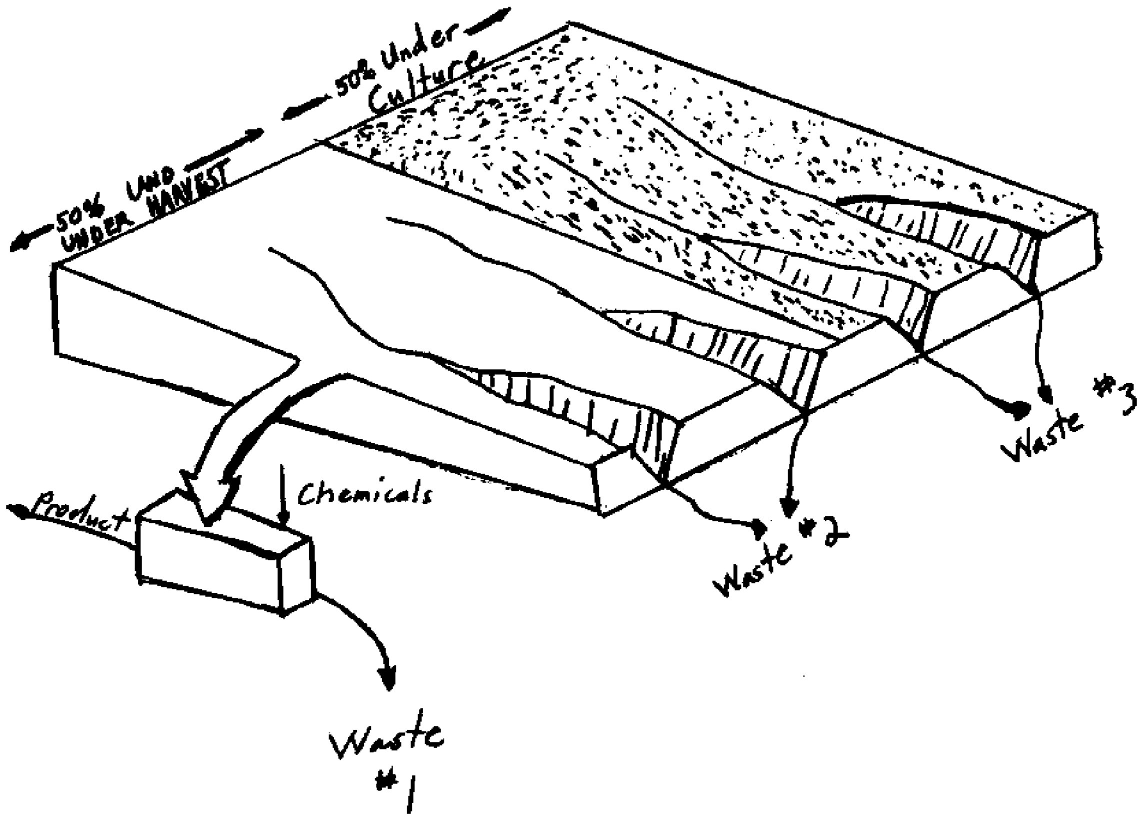


Diagram 3 Sugar Cane Industry as a Waste Generating System

CONCLUSIONS

The present Shoreline Protection Act is inadequate to properly protect the areas that it is concerned with. It is apparent that the boundaries that have been made are ineffectual in truly minimizing harmful effects on the marine environment and coastal areas. As was pointed out the boundaries need to be extended as far back as the highest point of land, due to the quick rate of run-off in the islands. As was shown with the California Shoreline Act, in some cases it is necessary to extend the SMA further in than just a few miles.

It needs to be pointed out that no point in the island chain is farther than 30 miles from the sea, and because of that fact it would be necessary to extend the perimeter of the Special Management Area to include all of the State, instead of just a small portion of it. Reasons for this have already been stated, and it should be recognized that Hawaii is an exceptional case for Coastal Zone Management and we have to treat it as such.

It has been suggested that the State adopt a Two Tier type of Coastal Zone Management program wherein the first tier be the boundaries set up by the counties, able to be changed at any time. The enforcing party for this tier would be the separate counties who will issue permits for any projects within their areas. All County and State rules and regulations, guidelines and objectives will be enforced in these areas.

The second tier of this proposed program will be all areas not included in the Special Management Areas set up by the counties. However, the State will be the enforcing agency and all its rules and regulations will only apply to Federal or State funded projects in that area.

There is a basic inconsistancy with the proposed plan and the goals that it has set up to follow in the Shoreline Protection Act. It has been shown that all of the State of Hawaii needs to be included in the SMA, and that all projects can effect our shorelines. But, if this two tiered program is enacted, then many activities will take place that could still be harmful to the coastal area.

However, the Two Tier program is a good one in that it invites public participation and county involvement in setting up the areas that they wish to protect. I think that basically the Two Tier program is an exciting innovation in Coastal Zone Management, but we need to include all activities in the second tier subject to rules consistent with sound conservation principles.

Also, stricter enforcement of rules and regulations is a must for the CZM program to work. It is necessary to keep in mind the goals that we wish to obtain in regard to our Coastal Area and we must work in that direction with changes when necessary.

Right now Coastal Zone Management is on the brink of taking a step in the right direction as regards the new bill being drawn up with the two tier program in mind, but change is continuous and must be constantly proded by concerned citizens who want a better shoreline.

REFERENCES CITED

Kendal, Henry and Glendenning, Robert Introduction to Geography, 2nd Edition, Harcourt, Brace and Company, Inc.; New York

A Bill for an Act, relating to Environmental Shoreline Protection. The Senate Eighth Legislature, 1975; State of Hawaii

Management of the Coastal Zone; Public Law 92-583; 92nd Congress, S. 3507, October 27, 1972

"Hawaii Coastal Zone Management Policy Plan" Honolulu Star-Bulletin & Advertiser, Feb. 27, 1977

"The CZM Relationship" Honolulu Advertiser, March 6, 1977

"Sewage Outfall May Revive Kaneohe Bay" Honolulu Star-Bulletin, March 3, 1977

THE KAHE ELECTRIC PLANT

by Hinda L. Diamond and Sarah E. Kennedy,
University Laboratory High School

The Hawaiian Electric Company proposed, in 1975, to add a fifth unit to their power plant, which is located at Kahe Point. No one opposed the building of the unit until construction had already begun. At that time the Nanakuli Surf Club realized that building the outfall for the fifth unit would result in the loss of a surfing site. They filed a suit against Hawaiian Electric and obtained an injunction to halt temporarily all construction on the unit.

After a month of meetings and proposals by the Nanakuli Surf Club and Hawaiian Electric, and agreement was reached out of court. Work on the unit was then resumed and the project completed in January of 1976.

This is a classic example of Shoreline Managment problems.

Introduction

This paper concerns the fifth unit which the Hawaiian Electric Company recently added to their Kahe electric plant, which is located near Nanakuli.

In the main body of the paper we discuss the salient points in the controversy which plagued the project soon after construction had been started.

We interviewed two people who had been involved in some way with the controversy: one from the Electric Company and the other from the Environmental Center at the University of Hawaii. We were also aided by several newspaper articles.

The Hawaiian Electric Company is currently operating an electric plant at Kahe Point, near Nanakuli, which supplies approximately one-third of the electricity for the island of Oahu.

The plant was built at Kahe Point because the area is relatively isolated. There is no great significance in the smoke which is produced by the plant, because it isn't a large amount, and when the trade winds blow, the fumes are directed out to sea. When there is a Kona wind blowing, the fumes are carried towards the Waianaes, the surrounding area of which is relatively uninhabited.[1]

Up until 1976, the power plant was operating with four units. In irder to operate the plant, water was taken into the plant at the shoreline and after going through the plant and cooling the system, it was discharged at the shoreline.

Located near the discharge area was a small keiki surfing sit, which beginning surfers frequented. The shallow sandy bottom made it easier for beginners.

In late 1975 the ElectricCompany decided that a fifth unit should be added to the power plant in order to cope with the increasing number of people on the island. The new fifth unit, which would have a new cooling system, would increase the rate of water pumped from 298,000 gpm to 448,000 gpm.

When Hawaiian Electric first applied for permits to build the fifth unit, they proposed to leave the water intake and discharge at their present location. The Federal Environmental Protection Agency outlawed the dumping of warm waste water directly into shoreline water, as the water discharged would be 10°warmer than the ocean temperature. They felt that the water should be discharged through pipes out into the ocean at a 40 foot depth. The present discharge had already damaged $\frac{1}{2}$ acre of coral, and it was speculated tha t with the added fifth unit, three acres of coral would be damaged and ultimately the coral would die.[2]

But studies done by Hawaiian Electric showed that this would eventually happen to the coral with the present power plant. The studies also stated that there would be no great harm done to fish because fish should be able to escape any such desyructive conditions. The studies found that fish would be killed only if they were not able to escape the thermal plume, or if they grew accustomed to the warmer water, and then suffered cold-shock if the discharge were to be temporarily discontinued.[3]

Hawaiian Electric maintained that the expenditure would be too great using pipes to such a depth, as the estimate taken on cost and effects was evaluating the value of coral at the highest price of land in Waikiki. So the company proposed to lay pipes to a 20 foot depth.

The Environmental Center at the University of Hawaii which had been keeping an eye on the Kahe project flet that one of the major concerns was sand displacement. Because the intake of water was right on the shoreline, a certain amount of sand went through the system and was deposited back on the shore by the onshore discharge. The Center felt taht it should stay this way, mainly because if the the discharge pipes were too long, the currents would not be able to bring the sand back to the shore, and it wouldn't circulate. The center suggested that the length of the pipes be limited. Then, upon further studies, they found that the sand which went through the system was very fine, and it didn't contribute to the beach in any substantial way.[4]

Upon studing the possible effects upon coral, fish, sand, and the like, the Environmental Center concluded that no real harm would be done by operating the fifth unit, and advised that the intake and discharge areas remain at the shore. Mr. Cox, a spokesman from the center, speculated that building long pipes would add on to everyone's electric bills.[5]

Finally, Hawaiian Electric and the Environmental Protection Agency agreed that the intake of water would remain at the shoreline, and the discharge would be done through pipes which were out to a 20 foot depth.[6]

Hawaiian Electric secured all the necessary permits, and held hearings, the main one was held in Makakilo, to which no one from the public attended, and nothing was said against the addition to the power plant.

Construction started in January, 1976. Then, in April two surfers, James "Bird" Mahelone and J. Tek Yoon, who were representatives from the Nanakuli Surf Club, filed a lawsuit against Hawaiian Electric stating that the Kahe Plant would destroy a prime surfing site. They also charged that the Environmental Protection Agency and the Department of Health issued permits for water pollution without preparing an Environmental Impact Statement, which is a require-by law under the National Environmental Policy Act.

The Environmental Protection Agency and Hawaiian Electric had agreed that the pipes must be out at least to a 20 foot depth. But in late April, Hawaiian Electric consultants found that the pipes wouldn't be laid to a significant depth, so an April 21, 1976, Hawaiian Electric requested a change in permit so they could put in pipes out to a depth of 27 feet. At the hearing on the 21st, twenty people attended and testified against the pipes, saying that they weren't wanted at all, and once again stated that the construction of the deep water outfall would ruin the surf site. In spite of thie, Hawaiian Electric received the permit.[7]

On June 15, 1976,with work on the fifth unit 40% complete, Federal Judge Samuel P. King ordered a complete halt on all construction until either the Army Corp of Engineers filed an Environmental Impact Statement, or Hawaiian Electric and the Nanakuli Surf Club could reach an agreement out of court to settle.

Hawaiian Electric fought the injunction, stating that the company was required by law to constructthe project, but the halt remaine d in effect.[8]

Judge King indicated to Hawaiian Electric in a later ruling that unless an agreement was made, there would be reason to issue a perma nent injunction which could delay construction for as long as 17 months. This was in spite of the fact that the judge had "grave doubts" that it was the "appropriate" remedy.[9]

It was costing Hawaiian Electric $10,000 every day the injunction remained valid, so they tried to settle out of court. It would take the Corp of Engineers at least six months to file an Impact Statement, and construction could not resume until the statement was complete, resulting in a high loss to Hawaiian Electric.

Various proposals and counterproposals made resulted only in disagreements. Some alternatives proposed by Hawaiian Electric were to license surfers and surfboards; provide free transportation from the Kahe surf site to other surf sites in the surrounding area; improve surfing equipment and techniques; all of which would add to current electric bills.

Finally, on July 9, after three days of trying to reach an alternative solution to a permanent injunction, Hawaiian Electric Company agreed to build an artificial surfing site, the first to be built in Hawaii, or give $250,000 to the Department of Parks and Recreation for making improvements on surfing sites along the Waianae Coast, between Barbers Point and Kaena Point.[10]

The agreement called for the construction fo a 200-300 foot articial shore which would be about 50 to 100 feet from the seaward wall of the water discharge system's basin. The waves created by the shoal would accomodate from five to ten surfers. Hawaiian Electric agreed to spend up to $250,000 to construct it. Hawaiian Electric said that it must obtain all the "necessary government approval, consents and authorizations by October 1, 1976." If this was not possible, Hawaiian Electric would then give the $250,000 to the Department of Parks and Recreation in ten yearly payments of $25,000. The agreement was as such because in building the shoal, Hawaiian Electric would use their existing trestle and equipment, which was already at the Kahe plant. The trestle had to be removed by late December beause of the normally heavy surf in that area during the winter. If Hawaiian Electric were to build the shoal without the use of the trestle and equipment already there, the cost of construction could climb to $one million. Last in the agreement was the provision that Hawaiian Electric would not be responsible for the upkeep of the shoal, should it be built.[11]

Moffat and Nichols Engineering firm was hired to design the shoal, with James "Kimo" Walker heading the design, for a fee of $40,000.

In exchange for Hawaiian Electric's construction of the shoal or giving money to the city, the Nanakuli Surf Club dropped their law suit against the company. Judge King then revoked the injunction and on Saturday, July 10, 1976, work was resumed for the first time since June 15.

The design committee drew up a plan for an artificial shoal, and the Army Corp of Engineers filed an Environmental Impact Statement on it.

A hearing was then held, where it was found that no one would be responsible for the upkeep of the shoal. It was not in the agreement for Hawaiian Electric to maintain it, and the Nanakuli Surf Club had neither the resources nor the funds to do such. Because of this, and because Hawaiian Electric was denied a permit by the State Board of Land and Natural Resources, the Army Corp of Engineers stated that the artificial surfing site would not be built.

Hawaiian Electric Company then offered the $250,000 to the Department of Parks and Recreation, but so far the money has not been accepted.[12]

The Kahe power plant is a specific example of economic use versus recreational use. Another example of this conflict is the building of the reef runway, which was constructed because of the problem of runway congestion and take-off over densely populated areas on the one hand versus a prime surfing site on the other.

Currently, the shoreline management boundaries encommpass such a small area that it really doesn't help solve such conflicts. What is really needed is a larger boundary, which will aid in solving similar conflicts, and perhaps preventing others from gaining the magnitude that the Kahe Plant controversy did.

Summary and Conclusions

We feel that the added fifth unit was an essential addition to the Kahe power plant. It provided a needed supply of electricity for the increasing number of people on Oahu.

We also feel that the surfing site, which was the center of all the controversy, was not a major surfing site; it was used mainly by beginners, and from our studies we found that the number of regular surfers at the Kahe surf site was minimal.

Mr. Cox from the Environmental Center at the University stated that no one can really improve a surf site, or any natural environment for that matter. We agreee, because once you start trying to change nature it usually just ends up getting messed up. We also think that HECO should keep the $250,000, as their offer of money to the city appears to have been a purely political move. Then the company could make improvements such as tables, restrooms, etc. themselves.

The most important point in our paper is the conflict between an economical use of the marine environment versus a recreational use. Perhaps if shoreline management could be applied more fully, similar circumstances could be avoided, or at least any differences could be solved before construction is started. Should construction be started, it always results in a loss to the company who is heading the construction, as was the case with the Kahe plant.

Footnotes

[1]Doak Cox, interviewed by Hinda Diamond and Sarah Kennedy (Environmental Center-University of Hawaii, Honolulu, Hawaii), 12:50 pm., March 1, 1977.

[2]John McCaine, interviewed by Sarah Kennedy (Hawaiian Electric, Honolulu, Hawaii), 2:45 pm., February 25, 1977.

[3]McCaine, Interview.

[4]Cox, Interview.

[5]Cox, Interview.

[6]McCaine, Interview.

[7]"Kahe Pipe Change Considered," Honolulu Star-Bulletin (April 22, 1976), p. B-3.

[8]Jim McCoy, "HECO's Kahe Discharge Starts," Honolulu Star-Bulletin (December 13, 1976), p. A-15.

[9]Ken Kobayashi, "HECO Agrees to Build Surf Site," Honolulu Advertiser, (July 10, 1976), p. A-12.

[10]Jim McCoy, "HECO, Surfers OK Plan for Surf Site," Honolulu Star Bulletin (July 10, 1976), p. A-7.

[11]McCoy, Honolulu Star-Bulletin, p. A-7.

[12]McCaine, Interview.

Bibliography

1. Cox,Doax,interviewed by Hinda Diamond and Sarah Kennedy,Environmental Center-University of Hawaii,Honolulu,Hawaii,12:50 pm,March 1,1977.

2. "Kahe Pipe Change Considered,"Honolulu Star-Bulletin,April 22,1976, p.D-3.

3. "Kahe Plant to Destroy Surfing Site,Suit Says,"Honolulu Star-Bulletin, April 14,1976.

4. Kobayashi,Ken,"HECO Agrees to Build Surf Site,"Honolulu Advertiser, July 10,1976,p.A-12.

5. McCaine,John,interviewed by Sarah Kennedy,Hawaiian Electric,Honolulu, Hawaii,2:45 pm,February 25,1977.

6. McCoy,Jim,"HECO'S Kahe Discharge Starts,"Honolulu Star-Bulletin,December 13,1976,p.A-15.

7. McCoy,Jim,"HECO,Surfers Disagree on Kahe Point Proposals,"Honolulu Star-Bulletin,July 4,1976,p.A-4.

8. McCoy,Jim,"HECO,Surfers OK Plan for Surf Site,"Honolulu Star-Bulletin, July 10,1976,p.A-7.

MARINE BIOLOGY

THE UTILIZATION OF ZOOXANTHELLAE PHOTOSYNTHATE IN THE DEVELOPMENT OF THE CORAL *P. DAMICORNIS*

by Joel P. Yuen, McKinley High School

Abstract:

The importance of the utilization of the products of zooxanthellae photosynthesis by the larval and adult stages of the coral *P. damicornis* was studied. Protein concentrations and the uptake of radioactive carbon in the larval and adult stages of *P. damicornis* indicate that the adult coral is more dependent on zooxanthellae photosynthesis for a source of nutrients than the coral larvae. The larval forms of the coral seem to utilize stored energy sources for metabolism.

Introduction:

Endosymbiosis between zooxanthellae algae and the coral P. damicornis has been studied since the 1920's by Edmundson (1, 2). Zooxanthellae algae are spherical dinoflagellates 8 to 12 microns in diameter. They are found intracellularly in the gastrodermal cells of the adult host in groups of 3 or less. Little is known of their biology as free swimming dinoflagellates or of how they infect host tissue (8).

Pocillopora damicornis is a familiar Hawaiian coral consisting of small fine branches. The adult coral colonies are comprised of coral polyps living in a protective skeletonal matrix. The adult polyps obtain nutrients by capturing plankton from surrounding waters and absorbing products of zooxanthellae photosynthesis as they are released by the algae. The utilization of the products of zooxanthellae photosynthesis by the adult coral has been studied extensively by Muscatine (7, 9).

The adult coral reproduces sexually and asexually. Asexual reproduction through budding forms new polyps. Sexual reproduction through gametes form coral larvae or planulae. These larvae are capable of creating new colonies through continued budding.

Planulae of P. damicornis are free swimming organisms approximately 1.5 mm in length. The larvae are club shaped, with clusters of zooxanthellae cells arranged in rows on their bodies. The planulae settle in 3 to 18 days, and do not feed during this period (10). Research on the symbiotic relationship between coral planulae and zooxanthellae has been done only on the observational level by Edmundson (2, 3) and Harrigan (4).

Problem:

The symbiotic relationship between zooxanthellae algae and the coral P. damicornis will be studied in the following areas:

1) the importance of the utilization of the products of zooxanthellae photosynthesis in the growth and development of the coral P. damicornis. The significance of the translocation of nutrients from algae to the coral will be studied in the larval and adult stages of P. damicornis.

2) the effect of a dark environment on the coral P. damicornis. The growth and development of the coral will be studied as affected by the loss of zooxanthellae photosynthetic activity in a dark environment.

3) the uptake of radioactive carbon by the zooxanthellae in the planula and the adult coral. Photosynthetic activity will be studied through the uptake of ^{14}C in the coral.

4) the distribution of the ^{14}C in the biochemical fractions of the adult and larva of P. damicornis. The utilization of the products of zooxanthellae photosynthesis into biochemical nutrients will be studied in the planula and adult.

Procedures:

Adult coral specimens of P. damicornis were collected from Ala Moana reef. The collected corals were placed in two uniform tanks. Water circulation between the two tanks was created through the use of pumps. Aeration in the tanks was also provided to create strong water circulation. One tank was subjected to a 24 hour dark environment by placing it in a dark box. The other tank was subjected to a 11 hour day, 13 hour dark environment.

A glowlux lamp was used to provide illumination.

Planulae were obtained from the coral heads in the light environment as soon as they were released. Planulation was also induced by leaving coral heads in stagnant water or water with strong agitation. For light and dark experimentation, planulae were placed in 600 ml beakers with 500 ml of filtered sea water. The planulae were then subjected to the same environmental conditions as the adult coral heads.

For the radioactive experiments, branches of adult corals and free swimming planulae were incubated with $NaH^{14}CO_3$. In the light experiments, the polyps and planulae were incubated for 24 hours under the illumination of a glowlux lamp. In the dark experiments, the coral polyps and planulae were incubated for 24 hours in a dark box. The polyps and planulae were incubated in 600 ml beakers with 499 ml of filtered sea water plus 1 ml of sterile H_2O pH 9.5 containing 20 microcuries of $NaH^{14}CO_3$.

Branches of adult corals and planulae under the experimental conditions were analyzed for protein concentrations following the Lowry Method for total protein (6). The number of polyps and planula used for experimentation was determined in order to relate the protein concentrations to the individual coral.

The coral branches and planulae incubated with $NaH^{14}CO_3$ were studied for the uptake and distribution of ^{14}C. The radioactive procedures used followed the fractionation procedures for small amounts of radioactive tissue as described by Lenhoff and Roffman (5).

Data:

Fig. 1. The graph shows the concentrations of protein in two corals. The corals were placed in a semi-dark environment for two weeks before experimentation. Both corals were exposed to a light for 24 hours before the first experiment (Day 0). The coral in the dark environment shows a continued decrease in protein concentration. The coral in the light shows continued high protein concentrations.

PROTEIN CONCENTRATIONS IN ADULT CORALS OF P. DAMICORNIS

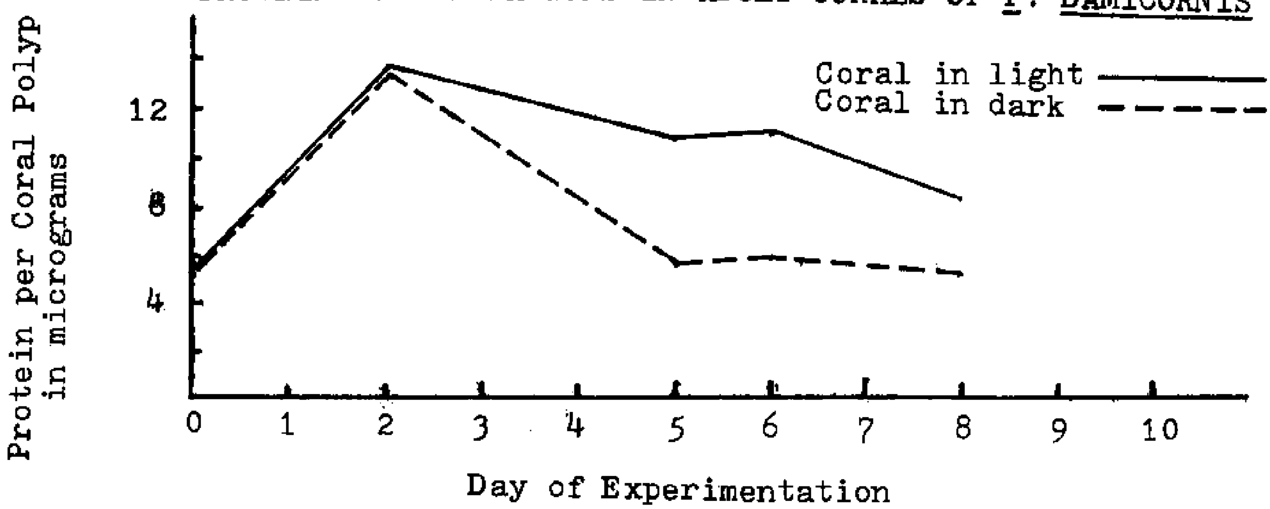


Fig. 2. The graph shows the concentration of protein per polyp in two corals. The corals were experimented upon one day after removal from the reef. Though there seems to be a variation in the concentration of protein in different coral heads, the coral in the dark continued to lose protein while the coral in the light increased slightly in protein concentration.

PROTEIN CONCENTRATIONS IN ADULT CORALS OF P. DAMICORNIS

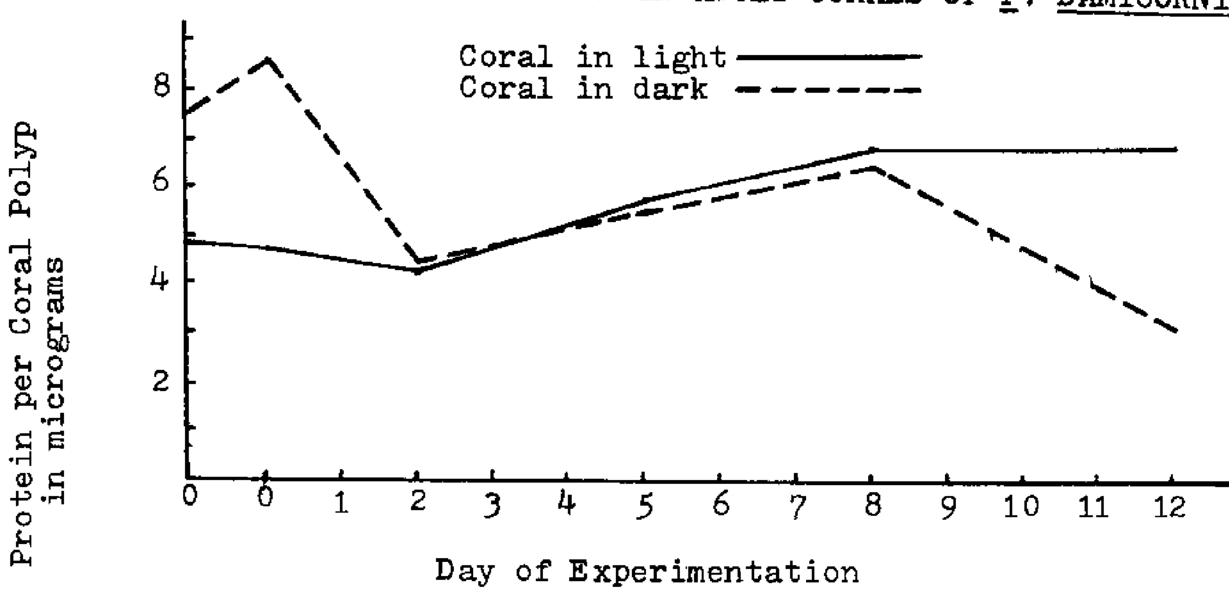


Fig. 3. The graph shows the relative uptake of radioactive carbon in the free swimming and adult stages of the coral *P. damicornis*. The uptake is measured in the number of radioactive particles counted per minute by a binary scaler. There seems to be greater ^{14}C uptake in the adult coral than in the planulae. Both planulae and adult corals show less uptake of ^{14}C under dark conditions.

UPTAKE OF ^{14}C IN THE ADULT AND PLANULA OF *P. DAMICORNIS*

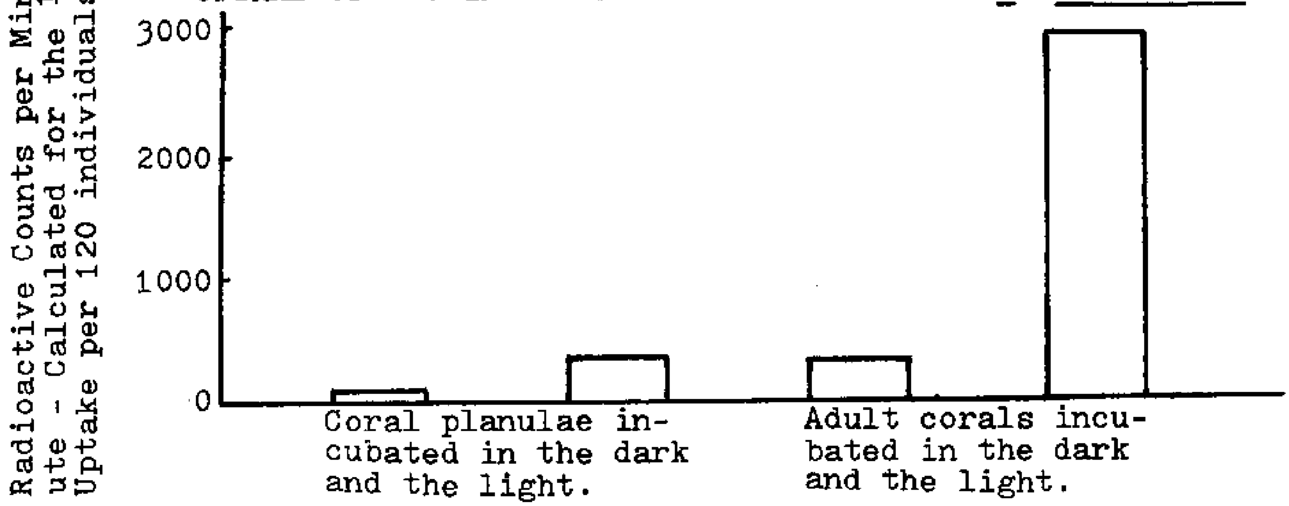
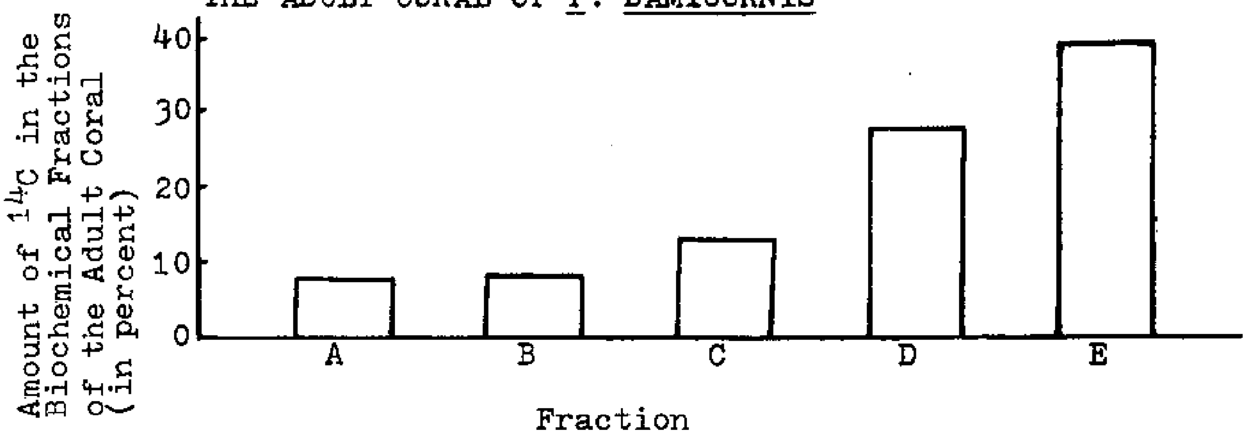


Fig. 4. The graph shows the distribution of ^{14}C material in the biochemical fractions of the adult coral incubated with ^{14}C. Most of the radioactive carbon was found in the nucleic acid and protein fractions.

DISTRIBUTION OF ^{14}C IN THE BIOCHEMICAL FRACTIONS OF THE ADULT CORAL OF *P. DAMICORNIS*



A Lipids and lipid soluble compounds
B Oligosaccharides, oligonucleotides
C Small molecules - amino acids, monosaccharides
D Proteins
E Nucleic acid components

Fig. 5. The graph shows a comparision between the concentration of protein in both the larval and adult stages of P. damicornis. There seems to be a higher concentration of protein in the larval stages than in the adult. The free swimming larvae have 360 to 500% more protein concentrations than the adult. The lowest protein concentrations in the larvae seem to be in the 2 week old settling planulae. However, protein concentrations are still 240 to 350% higher than those of the adult.

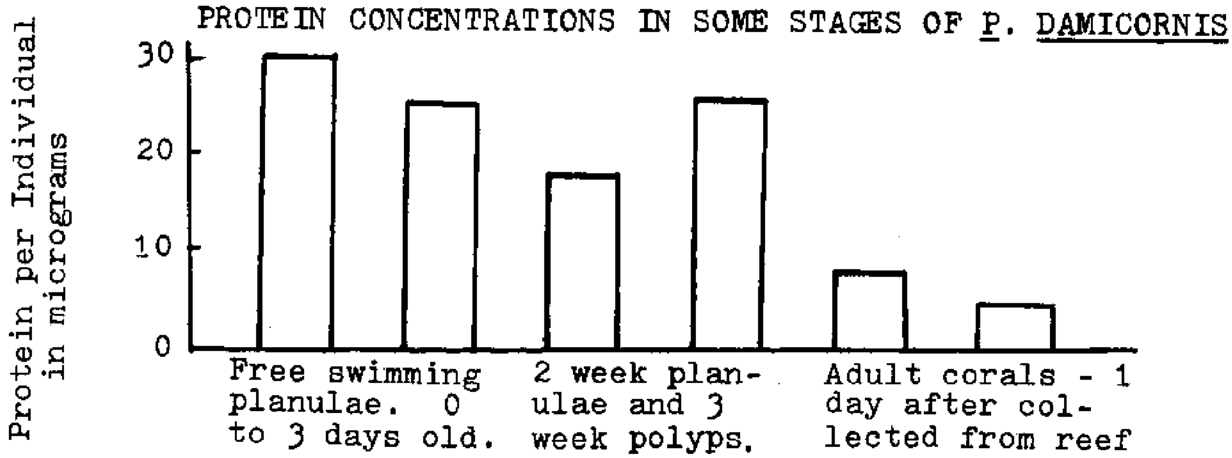
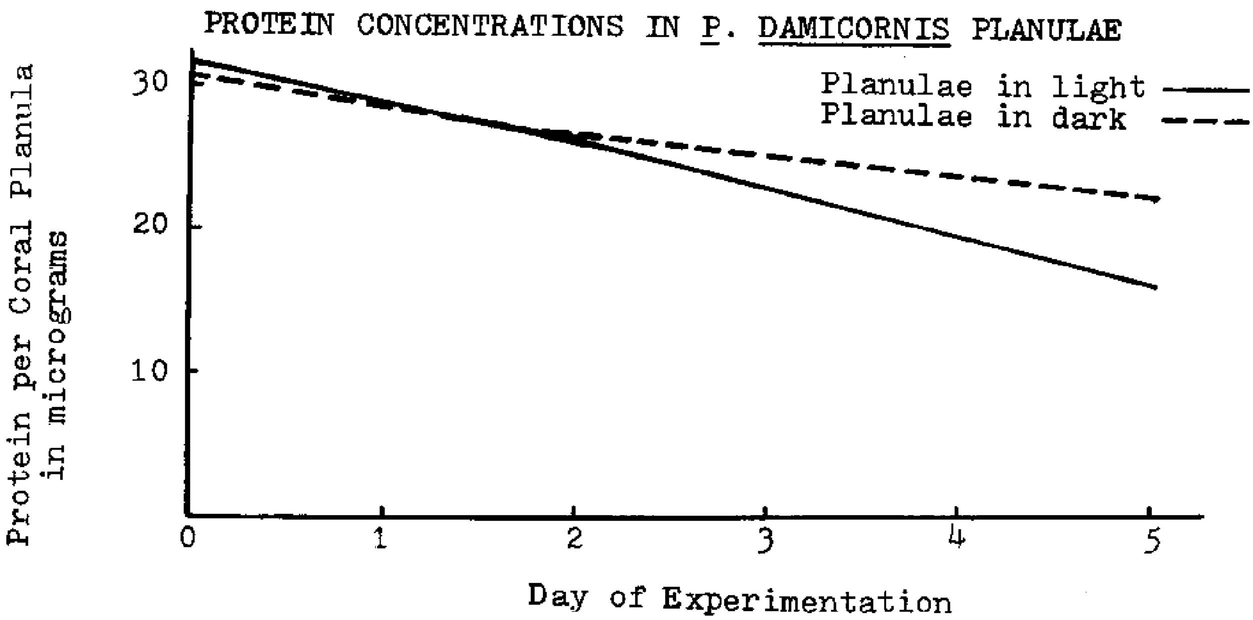


Fig. 6. The graph shows the protein concentrations of free swimming planulae. The planulae in both the light and dark environments show a general decrease in protein concentrations with age. The planulae in the light decrease faster in protein concentration than the planulae in the dark.



Discussion:

The protein concentrations of the corals in the dark environment were lower than the protein concentrations of the corals in the light (Fig. 1 & 2). The data seems to indicate a correlation between protein concentration and the amount of light the corals receive. This suggests that the loss of zooxanthellae photosynthesis in the dark is responsible for this decrease.

The lower protein concentrations in corals in the dark may may be due to two reasons. Researchers have found that coelenterate hosts may digest zooxanthellae when they are starved or when the algae no longer provide nutritional benefit (8). The loss of photosynthetic activity by the zooxanthellae under dark conditions may cause the coral hosts to digest the algae. In this process the protein in the zooxanthellae may be broken down by the coral into amino acids.

The loss of zooxanthellae photosynthesis may also hinder the coral host from synthesizing proteins. With the loss of the supply of nutrients from zooxanthellae the coral may utilize its other sources of nutrients solely for metabolism. The development of the coral host may then be hindered by the lack of adequate nutrients for protein synthesis.

The uptake of ^{14}C in the corals in the light was higher than the uptake of ^{14}C in the corals in the dark (Fig. 3). In photosynthesis, carbon in the form of carbon dioxide is utilized in the synthesis of glucose. The higher uptake of ^{14}C of corals in the light suggests a higher uptake of carbon in general. Thus, the uptake of ^{14}C in the corals suggest photosynthetic activity.

The distribution of ^{14}C in the biochemical fractions of the adult coral was found mainly in two fractions - the nucleic acids and proteins (Fig. 4). Because photosynthesis produces glucose, and not nucleic acids and proteins, a large portion of the products of zooxanthellae photosynthesis may be utilized for protein synthesis and production.

This data seems to correlate with the low protein concentrations in the corals in the dark. Both protein and radioactive experiments suggest that protein concentrations in the adult coral is dependent on zooxanthellae photosynthetic activity.

The protein concentrations of the free swimming planulae seem to be substantially higher than those of the adult (Fig. 5). The lowest protein concentrations seemed to occur in the 2 week old settling planulae. However, the protein concentrations in the settling planula were still higher than those of the adult.

The significance of the higher protein concentrations in the planulae may be two fold. In the adult stages of P. damicornis, the new polyps are developed through budding, or through asexual reproduction. The planulae of P. damicornis, however, are forms of sexual reproduction. The planula is able to create a colony of adult polyps through continued subdivision or budding. As a result, the high protein concentrations in the planulae, both in the free swimming and settling forms, may be necessary for new polyp formation through asexual reproduction.

The general decrease in protein in the planulae in their free swimming stages may be representative of the utilization of the protein for metabolism (Fig. 6). Because planulae do not acquire nutrients through the capturing of plankton (10), the only two alternative sources of nutrients are the utilization of products from zooxanthellae photosynthesis and the use of stored nutrient sources.

The higher uptake of ^{14}C by the planulae in the light indicates photosynthetic activity (Fig. 3). However, the uptake of ^{14}C in the planulae in the light was only 10% of the uptake of ^{14}C in the corals in the light. If the uptake of ^{14}C is indicative of carbon uptake in general, the lower uptake of ^{14}C in the planulae may indicate lower photosynthetic activity of the zooxanthellae in the planulae than in the adult. Because of the low ^{14}C uptake, a distribution of the radioactive carbon in the biochemical fractions of the coral planulae could not be determined. A larger sample of planulae or a larger dosage of radioactive carbon may be needed for an accurate determination of the ^{14}C distribution.

Because the low ^{14}C uptake by the planulae may be indicative of low photosynthetic activity, the planulae may not rely heavily on the translocation of nutrients from zooxanthellae for its development. The decrease in the protein concentrations in the planulae may indicate the utilization of protein as a nutrient for metabolism as its stored energy sources, the carbohydrates and lipids, are exhausted.

This hypothesis is supported in observational studies by researchers such as Edmundson (2, 3) and Harrigan (4). They found that although planulae in the dark could not survive over extended periods of time, the planulae did seem able to survive for long periods of time without the products of zooxanthellae photosynthesis.

The increase in the protein concentration of the 3 week old polyps (Fig. 5) may be due to an increase in zooxanthellae photosynthetic activity and the utilization of external nutrient sources through the capturing of plankton. This increase in protein concentrations in the 3 week old polyps may indicate an increased dependence on external sources of nutrients as its stored nutrients are exhausted.

The greater decrease in the protein concentrations of the planulae in the light (Fig. 6) may suggest a faster development of the larvae. Although the amount of photosynthetic activity in the planulae seem to be lower than the activity in adult corals, some products of zooxanthellae photosynthesis may be utilized by the planulae. These photosynthetic products may cause faster development of the planulae in the light environment.

Further research into the importance of the symbiotic relationship between the coral P. damicornis and zooxanthellae in the development of the coral is needed. The effect of the loss of photosynthetic activity on the concentrations of other biochemicals in the planula and adult coral should be studied. Measurements of the net photosynthetic rates in the planula and adult coral should also be made.

Studies on the utilization of ^{14}C in the planula and adult coral are needed to study changes in the types of biochemicals being synthesized from zooxanthellae photosynthetic products. The separation of algae cells from the coral tissue is needed for the direct edvidence of the translocation of nutrients from the zooxanthellae to the coral planula.

Conclusion:

The utilization of the products of zooxanthellae photosynthesis by the coral P. damicornis seems to increase with age. The planulae seem to rely heavily on their stored energy sources. The adult coral appears to be more dependent on the products of zooxanthellae photosynthesis than the planulae.

Literature Cited:

1) Edmundson, C. 1928. The ecology of an Hawaiian coral reef. The Museum, Hon., Hawaii. Bull. 45.
2) Edmundson, C. 1929. Growth of Hawaiian corals. The Museum., Hon., Hawaii. Bull. 58.
3) Edmundson, C. 1946. Behavior of coral planula under altered saline and thermal conditions. P. Bishop Museum., Hon., Hawaii. Vol. 18., Nov. 5, 1946., No. 19.
4) Harrigan, J. 1972. The planula larva of Pocillopora damicornis: lunar periodcity of swarming and substratium selection behavior. Thesis: Doc. Philosophy., no. 475., Univ. Hawaii Press.
5) Lenhoff, H. M., and Roffman, B. 1971. Two methods for fractionating small amounts of radioactive tissue. In Experimental coelenterate biology: H. Lenhoff, L. Muscatine, and L. Davis, ed. Univ. Hawaii Press. pp. 265-271.
6) Lowry, O. H., Rosebrough, N. J., Farr, A. L., and Randall, R. L. 1951. Protein measurement with the folin phenol reagent. J. Biol. Chem., 193: 265-275.
7) Muscatine, L. 1967. Glycerol excretion by symbiotic algae from corals and Tridacna and its control by the host. Science., 156: 516-519.
8) Muscatine, L. 1971. Endosymbiosis of algae and coelenterates. In Experimental coelenterate biology: H. Lenhoff, L. Muscatine, and L. Davis, ed. Univ. Hawaii Press. pp. 179-191.
9) Muscatine, L., and Cernichiari, E. 1969. Assimilation of photosynthetic products of zooxanthellae by a reef coral. Biol. Bull., 137: 506-523.
10) Reed, A. 1971. Techniques for raising the planula and newly settled polyps of Pocillopora damicornis. In Expermental Coelenterate Biology: H. Lenhoff, L. Muscatine, and L. davis, ed. Univ. Hawaii Press. pp. 66-71.

CROWN OF THORNS: CORAL REEF KILLERS
by Linda M. Tao, Hilo High School

INTRODUCTION

The Crown of Thorns,or Acanthaster Planci, is a starfish which inhabits the Indo-Pacific regions of the world.

This paper is about this animal,which has undergone a population explosion,and is destroying the reef building corals by eating their polyps.

I am writing this paper because I feel this problem is relavent to Hawaii. If the coral reefs of the islands of Hawaii are killed by these animals,it means reef life itself will cease to exsist. All that will be left is a algal encrusted coral skeleton,and a few herbivorous fish. When only this is left,that means all the reef fish the people of Hawaii use for food will be gone. Also the reef will not be the beautifully colored underwater jungle it is now, but a desolate,almost entirely lifeless underwater desert.

May I apologize now if this paper seems out of date as to the contents,but in gathering the research data for it,the latest materials the library had on the subject that I could find on it were published in 1972. However,eventhough some of the statistics are outdated,the basic facts remain.

The coral reef is an underwater world all its own. In it live many beautiful creatures that make their homes in the living coral reef. Menpachi,crabs,vana,parrot fish, trigger fish, surgeon fish,shrimp,sharks,and a whole list of other animals,and plants inhabit this colorful world in a world.

Then suddenly this colorful living world becomes a desolate,algal covered graveyard. Coral killed by a preditor. A starfish called the Crown of Thorns.

The Crown of Thorns. Its scientific name is Acanthaster Planci. It can be up to 28 inches in diameter,but the average adult is 12-20 inches in diameter. The amount of arms varies from as few as 9,to as many as 23.

The Crown of Thorns is the only known venomous starfish. Its spines are covered with a venom producing skin. That's how it got its name,Crown of Thorns. These spines can be 3 inches long or longer.

The spines are very brittle and can break of easily in a wound. The venom causes severe vomiting,swelling,faintness, numbness,lethargy,extreme pain,and even paralysis. If these spines are not removed quickly and completely,secondary complications develop.

The starfish is well camoflagued against the colors of corals and plants of the reef. The upper part of the starfish's body disk, is colored by many different colors.Grays,fawns,with reds and greens predominating. A bluish-gray,almost black hue, colors the upper surface of the arms. The tips of the spines are usually red or orange in color.

As mentioned in introduction,the creature's habitat is the coral reef,and they can be found exposed at low tide,or up to depths of a 150 feet.

Before the population boom, the starfish was a relativly rare creature of the reefs.

The Crown of Thorns'breeding season lasts about a month, starting between January-December. However further research has indicated that it may last longer than it first appeared to be.

During the breeding season, the gonads in both the males and females enlarge to occupy a greater part of their bodies. The starfish tend to gather in large groups during this period.

A female that's 14 inches in diameter,releases 12-14 million eggs into the water. The male then releases milky white clouds of sperm into the water,that meet the eggs,and fertilise them externally. The eggs then develop into microscopic free-swimming larvae,which become part of the planktonic community. In this microscopic world,they have many preditors,such as tiny crabs,shrimps,crayfish,and also the coral polyps. These larvae are capable of traveling long distances depending on the weather and currents.

The larvae land on the coral reefs where more of them are eaten by the polyps. The survivors however develop into infant Crown of Thorns which look like the adults. How long the larval stage lasts is not really known,but is believed to be kind of short.

During the first 2 years of life,the juvenile Crown of Thorns grows about ½ inch each month. When they get to be 12 inches in diameter,the are ready to mate. It is believed that the older the starfish gets the slower it grows. Their life span is believed to be 6-7 years.

As areas of coral are destroyed,the preditory pressure on the larvae are lessened,thus more and more of the species survive,with each breeding season.

When the reef has a normal balance of life,the coral polyps inter-relate with the Crown of Thorns with no problems. But if the Crown of Thorns reach plague proportions,it is logical to assume that they would feed on the polyps solely,as they are the most readily available source of food.

The starfish seem to feed on all types of reef building coral polyps. It sometimes is seen to eat 2 species of soft corals(Alcyonarians),but it avoids the Millepora Sp.,commonly called fire corals.

The starfish has no sensery system as we know it, It has no sense of sight and it is also probable that it has no hearing either. It seems to respond to vibrations during sonic tests. It does have a sence of touch in common with man,and appears to respond to a primitive sense of smell. In tests,Crown of Thorns specimens were placed between a patch of living coral and a patch of dead coral, The starfish headed for the live coral. It is possible that the starfish have some kind of chemical reaction to the stimule emitted by dead or living coral. This however is still not known.

There is evidence that when they have devistated one patch of reef they migrate in masses to a fresh patch. Since the animals have no eyes, how they giude themselves is a mystery.

The preditors of the Crown of Thorns include the coral polyps, which eat the larvae, Neaxius, a crustacean, which is red, and looks like a miniature lobster. The Triton or Trumpet Shell (Charonia Tritonis), the Helmet shell (Cassis Cornuta), sharks which now and then will eat the starfish who's venom seems to have no effect on the shark. The coral shrimp (Hymenocera Elegans), is an elegant creature, which is about 2 inches long, and a preditor of the Crown of Thorns. It inhabits the Indo-Pacific region. They are usually seen in pairs.

Some authorities theorize that the plague is a cyclic phenomenon. This means that starfish plagues like these, happen every so often. But, if this is so, why then no legends or folklore among the people of the areas infested by these creatures? Other authorities believe the plague is due to a fundemental change in the ecological balance. Another theory is the the plague is not a natural occurance, but that it has been influenced by man.

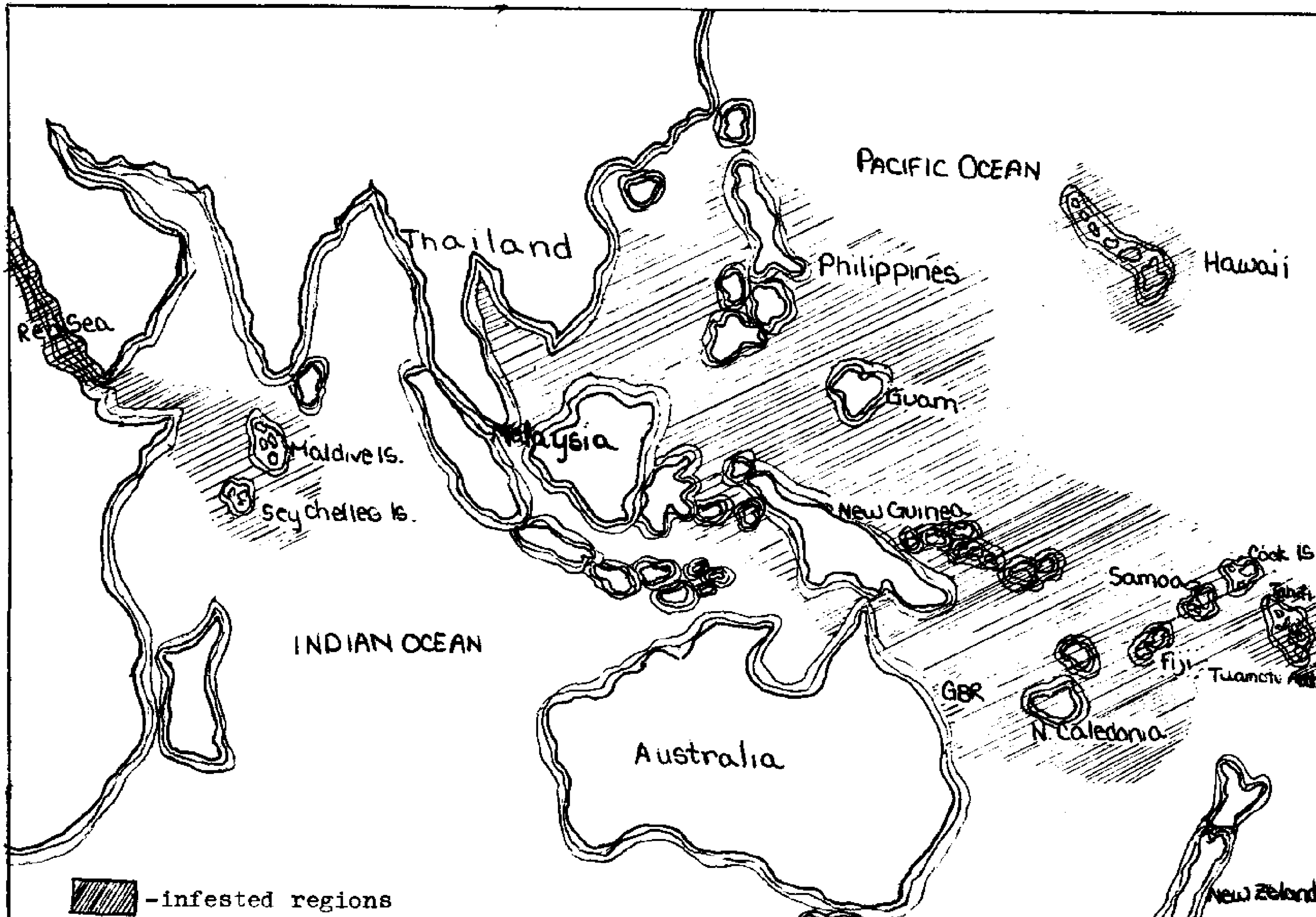
The starfish plague could also have been caused by pollution of the sea, which reduces the preditory pressures on the species during its early life. Pollution caused by industrial pollutants, increase in drilling and transportation of crude oil, and development of petrochemicals,both organic and inorganic wastes. Also the blasting and dredging of coral reefs in certain areas, kill the coral,which reduces the preditory pressure on the larvae.

The Crown of Thorns as stated in the introduction,inhabit the Indo-Pacific regions. In the 1960's serious outbreaks of the Crown of Thorns were reported in widely spread areas of the Indo-Pacific region. The areas reported infested by the starfish were,the Hawaiian Islands,across the Pacific to the Indian Ocean, and even to the Red Sea. U.S. Trust Territories in the Pacific, Mariana,Caroline,and Marshall Islands,French Polynesia,Western Samoa,New Caledonia,Papua,New Guinea,Solomon Islands,Thailand, Phillipines,Malaysia,and Australia. In the Indian Ocean,the Maldive Islands near Ceylon,the Seychelles Islands(off the coast of Africa,also in areas of the Red Sea.(See map on pg.6)

In their final report to the U.S. Dept. of the Interior, (1969),the Westinghouse Research Labratories,who had survey teams in the U.S. Pacific Trust Territories,and the Hawaiian Islands, required additional survey time to continue their study of the Hawaiian Islands. They were particularly concerned with a large population of the starfish they found on Molokai.

In 1970, Hawaii was reported to be an infested area,as seen on the map on pg. 6.

Some means of controlling the starfish are;hand collecting of the starfish,killing of the starfish using an injector gun containing formalin,formaldehyde,or ammonium hydroxide(which removes any danger of pollution becauqe amonia accurs naturally in the marine enviroment).



Map; Reported Infested Areas in 1970

Before the use of injector guns,hand collection was used. A sword-like instrument was used to spear the animals. The divers would surface with 20 or 30 starfish jammed onto the rod,and would put the starfish in the boat,to be taken ashore and buried. The starfish die quickly out of water. They seem to dehydrate.

In U.S. Trust Territories a team of divers are employed to kill the Crown of Thorns with injector guns. This has helped to protect the beautiful coral areas around Guam and surrounding atolls.

In the Islands of Hawaii, hand collecting and injector guns were used.

Some possible solutions to this problem that have been suggested are:biological control(using known preditors of the Crown of Thorns,and produce them in controlled conditions to release on the reefs). But before one can use this method of control,one has to think about its effect on the rest of the inhabitants of the reef. You don't want to solve one problem,and create another.

When sonic waves were experimented with on 8 Crown of Thorns specimens,as a means of repelling them,after 30 minutes of continueous transmitting,2 of the largest starfish died. After 48 hours of observation, the 6 small starfish suffered no ill effects. This experiment took place in a land based tank, in Australia. To see if sonic wave barrier would work to repell the starfish movement,further experiments would have to be done on the reef,because the closed in tanks distorted the sound and a pure tone couldn't be found. But because of certain circumstances,the experiment was never completed.

CONCLUSION

In this paper I have attempted to show that the Crown of Thorns could be a potential threat to Hawaiian coral reefs,and its outcome if this is allowed to happen. This will hurt the people of Hawaii by ruining the beauty of our reefs,and the fun and pleasure people get out of using the reef as a source of recreation,and as a source of food too.

Hawaii has her reefs that have a beauty and quality all their own,which I think we should be proud of and protect.

I feel that if pollution is the reason for this sudden population explosion,or even if it isn't,man must find ways of preventing pollution of the ocean,and land and air for that matter. Because if he doesn't find a way,the ocean will eventually die and the world will become just a huge garbage dump.

But as for getting the present problem under control,I feel the most practical solution at this time would be to use divers with injector guns and hand collection,although it is time consuming,it seems to be the most enviromentally safe,and successful method in use at present.

BIBLIOGRAPHY

BOOKS

1. Bridges,William. 1970. The New York Aquarium Book of the Water World. New York: American Heritage Press.

2. Brown,Theo,and Kieth Wiley. 1972. Crown of Thorns the Death of the Great Barrier Reef? Sidney. Angus and Robertson(Publishers)PTY LTD.

3. Chesher,Richard H. "Coral Reef in Jepordy." Science Year,the World Book Annual. 1970. Chicago, Field Enterprises Education Corporation. pg. 110-124.

REPORT

1. Westinghouse Research Labratories. 1969. Acanthaster Planci:Impact on Pacific Coral Reefs. Pittsburg.

ARTICAL IN A JOURNAL

1. Sugar,James A. 1970. "Starfish Threaten Pacific Reefs". National Geographic. Vol. 137. No. 3. pg. 340-352.

AFRAID OF EELS, SHOULD WE BE?

by Arlene D. Bazell, Pahoa High School

Afraid of Eels, Should We Be?

Abstract

In a probe into the generally unknown territory of the eel, the questions are asked; Should we fear the eel? Do they attack for no reason at all? Or are they provoked?

To answer these questions there are experiences from books, personal experiences, and the professional views of doctors. All of these tend to point into one direction; No we shoudn't fear the eel. No they don't attack for no reason. And yes, they need to be provoked.

Afraid of Eels, Should We Be?

Introduction and Problem

Ever since I learned how to swim a question has been bothering me. Why do so many people, including myself, fear the eel? I have encountered many face to face but now that I think back, all of these times the eel seemed to have fleed from me as fast as I from it. If it is so, that the eel is as afraid of me as I am of it, why, then, are there so many stories of these "feirce" creatures attacking people for no apparent reason? Were they really provoked into attacking? Are the stories just figments of vivid imaginations? All these questions I must answer for myself.

There are sixty-one species of eels known to Hawaii. Of these the Chilorhinus platyrynchus, the Moringudae marochir, the Caecula platyrhyncha and the Conger marginatys are quite common. How ever, the most common eels of Hawaii are those in the family of Muraenidae, the moray eel. There are thirty-one species known to Hawaii of which of all are said to be the feircest of all eels, even the conger, or also known as the white eel, are said to be less aggressive then the moray. But again, could the truth been stretched?

Of the many species of moray, three generally well known species are the Brown moray, the Black-Speckled moray, and the Zebra moray.

The Zebra moray is oviously known for its ochre-black body with numerous narrow white bands endircling its body. It is the only eel with this marking so it is easily identified. Most Hawaiian eels are small, under five feet. The Zebra moray is no exception. It reaches a length of three feet.

The innumerable, small, well-defined, dark specklea on a light ground will imediately distinguish the Black- Speckled moray from all other species. This relatively small eel reaches a maximum length of two feet.

The Brown moray is undoubtedly the most common eel in Hawaii. But unlike the oth er eels described, they have no outstanding markings. There color ranges from grey, through brown, to charcoal black.

The Brown moray is abundant every where along rocky shores in water less then forty-five feet. It spawns in May. Seventy percent of the new population are born with isopod parasites in one or more of the gill cavities but it is unknown whether it eventually kills the fish or not. The species reaches a maximum of two feet.

Materials and Methods

I have encountered many eels accidently while swimming in tidepools, and I have noted their reactions to me. All but one of them fleed from me. Most of the information I have gathered was from books and other peoples personal experiences with eels. I must say I've never been able to go out, turning rocks, looking for and hoping to find eels. I'd rather not meet up with the creatures.

Only once have I encountered an eel which was not afraid of me (and I was not afraid of it) It was a baby Brown moray, maybe a total of six inches long, which calmly swam across my foot as if it were part of the rocky ocean floor and down into a near by creavise. It showed me no aggressiveness nor eagerness to attack the way the fish stories imply. Oth er then this eel, all the eels I've meet up with where too afraid to swim any further then they had all ready. Both of us swimming in opposite directions very quickly.

In the book Sea Treasures by Kathleen Yerger Johnstone, the author noted a story told to her by a rare shell collector. He told that once when he was looking for shells in about eight feet of water, when he tirned a rock and out shot a large moray eel. The water was murky from the sand that floated around from all the commotion so he couldn't see where the eel had gone. He felt it would be saftest if he stood still until the water cleared so he could see the eel. When it did he was standing face to face with the eel.The shell collector claimed that the eel shot forward at him so he raced to the shore. "And made it!", he claimed. He was possitive that the eel had darted at him and not away from him, but had it? Would it have really been possible for him, a land dwelling animal, to out swim an eel, a water dwelling fish?

Another accounting of eels from this book said that a boy had been scuba diving off the Sombrero Reef Light on Key Vaca about five miles from the shore. The boy had been bitten by a thirty-four pound eel and the eel had to be pride off by the boys diving companions. When the boy had been asked if he had provoked the eel in any way or if the eel had simply attacked, the boy replied that he didn't blame the eel for attacking but he hadn't purposely provoked the eel. He just swam to close, unknowingly, to the eels lair.

Couldn't there have been a justifiable reason like this one for all the attacks on man made by eels?

When I asked a friend who often goes skin diving at night if he had ever encountered eels he looked at me as if I were stupid. He said, " Hundreds. Eels feed at night." I asked him if any of the eels had ever chased him. He said only once but the eel had really followed him. He wanted to see what the eel would do if he shined a light into the eels face. Sure enough, the eel followed him around like a puppy dog for as long as he shined the light in its eyes. Even as he got out of the water, still shining the light on its eyes, the eel tried to follow. It was as if the light had hypnotized the eel. He said other then that particular inccident the eels went along their seperate ways, hunting for fish and octopus.

An accounting made by Jacques Cousteau in the book he wrote <u>Life and Death in Coral Sea</u> made it a little more clear as to whether eels need to be provoked into attacking. Cousteau wrote that while he and the crew were doing a particular study which involved the feeding of fish by hand, daily, an eel decided to get its share of food. Omer backed away to see if the eel would leave its lair completly for the food while they were standing there. The eel hesitated at first but soon came out without viciousness toward Omer while it gently took the food and went back to its lair. After several minutes of feeding the eel, Omer succeeded in doing something he longed to do but feared the eel would attack him for. He patted the eels head without causing it to flinch.

"If we had been able to stay there for two or three more days, the eel would have come to recognized Omer and would have followed him about like a dog on land." says Cousteau.

The moray eel has formidable teeth and can be dangerous if he is provoked. Never-the-less, despite its forbidding appearance and reputation it can be tamed, as Yves Omer has proven.

Afraid of Eels, Should We Be?

Materials and Methods

After reading these articles I realized that the truth could have been stretched in writting them. I needed more proof. The only way I knew to turn was to the doctors who had treated patients for eel bites. I called thirteen different doctors and asked if they had ever treated any one for this. After I called about five doctors I was sure it was a lost cause. All of them had said no. But them when I called Dr. Harguchi, he said he had, quite recently. The patient had been catching lobsters when he thought he saw one under a rock. He reached under only to find it was an eel. Naturally the eel bit him.

About three other doctors had said they had treated patients within the year 1976, but they weren't sure of how it happened. One doctor said" Why ask? Who would tell the truth and say they were dumb enough to reach into an eels lair anyway?"

When I called a medic clinic I talked to a docter who said he had treated several patients, one quite recently. A tropical fish collector was trying to loosen his net when he reached across the front of the eels lair. To an eel, who doesn't know you didn't intend to cross its path, you are provoking him.

The doctor had also said that he had treated several children for eel bites when he worked as a doctor on Oahu. The doctor said he was sure that the children had unintendedly provoked the eels.

Results and Conclusion

As a result of the investigation I've made I feel it is safe to answer the questions that have been on my mind. No, people do not have to fear eels. They should have great respect for them in every way, because they are living animals but mostly because they can do bodily harm if provoked. As for the stories told, either they were exagerated greatly or the story-teller left out the part about provoking the eel. I think that an eel will not attack for no reason at all. Whether or not we may think it is a logical reason, there must be a good reason, to the eel, for attacking.

Afraid of Eels, Should We Be?

Results and Conclussion

I personally feel that the main reason for eels attacking is invasion of territory. A person stepping in the general area of the eels lair may not intend to invade the eels home. However to the eel this is probably an aggressive act to take over its territory. And all the more reason an eel would bite, if you stuck your hand or foot into its hole. Eels are very protective of their home. therefore will bite anything that treatens it.

Since we are not sure exactly what aggrevates an eel or what in its terms is being provoked, it would be best to steer completely clear of eels whenever possible. Or at least be cautious of them.

Afraid of Eels, Should We Be?

Bibliography and Refferences

* Adams, M.D. Feb. 15,'77
* Adler, M.D. Feb. 15,'77
* Boone, M.D. Feb. 15,'77

Bridges, William
The New York Aquarium Book of the Water World

* Carvalho, M.D. Feb. 15'77
* Casile, M.D. Feb. 15'77
* Chin, M.D. Feb. 15,'77
* Ching, M.D. Feb. 15,'77

Cousteau, Jacques
Life and Death in Coral Sea

Engel, Leonard
The Sea

FraserBrunner, Alea
Danger in the Sea

* Geiger, M.D. Feb. 15,'77

Goodsen, Gar
The Many Splendored Fishes of Hawaii

Gosline, W.A. and Brock, V.E.
Handbook of Hawaiian Fishes

* Griffith, M.D. Feb. 15,'77
* Hamasaki, M.D. Feb. 15,'77
* Harguchi, M.D. Feb. 15,'77
* Harvey, M.D. Feb. 15,'77

Afraid of Eels, Should We Be?

Bibliography and Refferences

Herald, Earl S.

Living Fishes of the World

* Hesterly, M.D. Feb. 15,'77

Hobson, E.S. and Chave, E.H.

Hawaiian Reef Animals

Miller, Robert C.

The Sea

Johnstone, Kathleen Yeger

Sea Treasures

National Geographic Society

Wonderous World of Fishes

Straughen, Robert P.L.

Exploring the Reef

Time Life Television

Dangerous Sea Creatures

Waters, John F.

Giant Sea Creatures

(* information obtained by phone on date indicated)

SOME STUDIES OF THE BIOLOGICAL EFFECTS OF THE TOXIN HOLOTHURIN ON MACROBRACHIUM LAR, KUHLIA SANDVICENSIS AND PALAEMON DEBILIS

by Catherine F.T. Uyehara, McKinley High School

ABSTRACT

Extraction of the toxin holothurin from Actinopyga mauritiana was completed. The toxin was tested on the cardiac activity and respiratory systems of both invertebrates and vertebrates. Different concentrations were utilized on Macrobrachium lar, Kuhlia sandvicensis and Palaemon debilis to determine LD_{50}. Results were LD_{50} concentrations of 2.0×10^{-4} g/ml, 1.58×10^{-8} g/ml and 2.94×10^{-4} g/ml respectively. The effectiveness of holothurin as a hemolytic agent was investigated with toxicity tests on human red blood cells. The cells lysed immediately when exposed to a concentration of 2.54×10^{-9} g/cell.

INTRODUCTION

The Cuvierian tubules and body walls of certain species of holothurians, or sea cucumbers, contain a substance designated as holothurin. It is toxic to a wide range of plants and invertebrates and probably protects the seemingly harmless creatures against predators (Chanley et al., 1959).

The chemical analysis of this substance shows it to be a type of steroid glycoside. It is heat stable and soluble in water and ethanolic solutions (Chanley et al., 1959).

Since holothurin has neurotoxic, hemolytic, antifungal and antitumorous properties, (Nigrelli and Jakowska, 1960), it shows much pharmacological potential.

Toxicity tests indicate holothurin affects invertebrates such as crustaceans, mollusks, annelids, echinoderms and protozoa, resulting in a variety of reactions. Among these reactions are the inhibition of growth, creation of developmental faults, and lethal effects (Nigrelli and Jakowska, 1960).

Tests with vertebrates have shown the following: Holothurin A, extracted from the Cuvierian organs of the Bahamian cucumber, Actinopyga agassizi, is toxic to 50% of mice tested when given intraveneously at a LD_{50} dosage of 9 mg/kg (Friess et al., 1960). Death occurred within 1 minute at dosages near the LD_{50} point. The same toxin tested on fish resulted in reactions from simple irritation to death, varying with time and dilution (Nigrelli and Jakowska, 1960). Holothurin on a frog nerve-muscle preparation is comparable to cocaine, procaine and physostigmine. It has a strong and irreversible action on nerve and has a contractile effect on muscle (Friess et al., 1960). Holothurin also reduced the growth of tumor cells in mice (Nigrelli and Zahl, 1952). Furthermore, this same toxin lysed rabbit red blood cells, showing a characteristic analagous to saponin, and produced hemolysis when injected in the dorsal lymph spaces of the frog Rana pipiens (Nigrelli and Jakowska, 1960).

The purpose of this project is to examine the biological effects of the toxin, holothurin, on animals -- particularly the circulatory and respiratory systems. Is holothurin a stimulant, inhibitor, or hemolytic agent?

The organisms tested were Macrobrachium lar (fresh water - brackish water prawn), Kuhlia sandvicensis (salt water fish or aholehole), and Palaemon debilis (salt water shrimp or opae). These organisms were chosen to determine the effectiveness of holothurin under varying environmental conditions. Specifically: 1) the difference in response by two species of shrimp, one fresh water and the other salt water, with similar structural characteristics and 2) the difference in response between invertebrates and vertebrates (vertebrates appear to have more complex circulatory and neurological systems so the toxin could have a different effect).

Since quantitative studies of the effect of holothurin on human blood cells have not been reported, an investigation utilizing holothurin as a human hemolytic agent was initiated.

MATERIALS AND METHODS

Preparation of Toxin:

Actinopyga mauritiana was collected from Kaneohe Marine Corps Air Station, Magic Island, Kaloko Cove, Oahu and Hanapepe, Kauai. (This species was utilized because of its accessibility in local waters.) The toxin holothurin was extracted by a modification of the method of Chanley, (Chanley et al., 1966), from Cuvierian tubules collected through dissection from 100 sea cucumbers. The result was 3.2 g of the solidified glycosides.

Toxicity Tests:

Tests on Macrobrachium lar: A stock solution of 1 gram of the holothurin crystals per 1 liter of water was made. The possibility that effects on the organisms were due to the pyridine or hexane utilized in the extraction procedure was tested. Since the organisms placed in beakers rinsed with pyridine and hexane remained alive, this investigator concluded that toxicity was not due to these solvents.

A total of eleven prawns were exposed to 50 ml solutions of different concentrations. 2 - 3 organisms were tested at each dilution of 1:1, 1:3, 1:5 and 1:7. The weights of each prawn were recorded. Gill bailer movement per 5 second intervals and heart rate per 10 second intervals were counted.

Tests on Kuhlia sandvicensis: The same stock solution was utilized. In addition to the hexane and pyridine controls, the same amount of fresh water as the amount of extract used was added to the salt water of a third control. This tested the possibility of an effect of fresh water on the marine organism, since the toxin was dissolved in fresh water. No effect was apparent for all three controls.

A total of eighteen aholehole were exposed to 50 ml solutions of dilutions of 1:3, 1:7, 1:15, 1:99, 1:499, 1:4999, 1:9999, 1:19,999, 1:39,999 and 1:79,999 with 1 - 4 organisms tested at each dilution. Weights of fish were recorded.

Respiratory rate per 10 second intervals was taken.

<u>Tests on *Palaemon debilis*:</u> A new stock solution of 1 gram of holothurin per a liter of filtered salt water was prepared for the salt water organisms so as not to introduce effects of changes in salinity.

A total of thirteen opae were exposed to 50 ml solutions of 1:1, 1:3 and 1:7 with 2 - 5 organisms tested in each dilution. Weights of shrimp were recorded. Heart and respiratory rates per 5 second intervals were counted.

<u>Tests on Human Red Blood Cells:</u> A 0.9% saline ph 7 buffer solution was prepared. Blood samples were set up by mixing 0.05 ml blood in 9.95 ml saline solution. A toxin solution of 1×10^{-5} g holothurin/ml saline solution was made.

The spectronic 20 was used to determine the rate at which the toxin acted upon the blood. The hemocytometer was utilized to establish the concentrations of red blood cells per ml of solution and also helped determine the manner in which the toxin acted on the blood cells.

The original concentration for each sample was about 1,966 red blood cells/ml saline. 0.5 ml of the toxin solution was added to 9.5 ml of each blood test sample. The concentration of the amount of toxin acting on a blood cell was 2.54×10^{-9} g toxin/red blood cell. The same amount of saline solution as the amount of toxin was added to the controls to account for any change in concentration of the test samples due to the addition of the toxin solution.

Another standard control was made to compare the percent transmittance and the number of cells in different dilutions and the percent transmittance and the number of cells after exposure to the toxin. Blood samples were diluted with saline and the number of cells in each corresponding percent transmittance was recorded.

11 tests with the spectronic 20 and 8 tests with the hemocytometer were run. Of these, 6 tests were run simultaneously.

RESULTS

Tests on *M. lar*, *K. sandvicensis* and *P. debilis*:

The concentrations for 100% mortality were 2.5×10^{-4} g/ml for *M. lar* (prawns), 1.25×10^{-4} g/ml for *P. debilis* (opae) and 5.0×10^{-8} g/ml for *K. sandvicensis* (aholehole). The results of the toxicity tests suggest 2.0×10^{-4} g/ml as the LD_{50} point for prawns, 2.94×10^{-4} g/ml as the LD_{50} point for opae and 1.58×10^{-8} g/ml as the LD_{50} point for aholehole.

Heart rate increased before decreasing for both the prawns and opae after exposure to the toxin. Response to the toxin was immediate for the prawns and aholehole. Reactions were irritability and jerky movements. As the concentration utilized decreased, time of death increased for the prawns and aholehole. The dilution utilized did not affect the time of death of the opae. Although the activity of the opae slowed down after exposure to the toxin, the heart and respiratory rates remained the same until a short while before death. The respiratory rate of the aholehole remained the same until a short time before death when there was a sharp drop in gill movement which could not be recorded since the fish started convulsions.

Tests with Human Blood:

The toxin acted upon the blood cells and blood components instantaneously. An average of 41.38 cells (10,000s/ml) reduced to an average of 0.46 cells (10,000s/ml) within 26 minutes after exposure. The percent transmittance, indicating the amount of blood substrate acted on, increased on the average from 16% - 45%.

DISCUSSION

It is apparent from the tests on *Macrobrachium lar* (fresh water - brackish water prawn), *Palaemon debilis* (salt water shrimp or opae) and *Kuhlia sandvicensis* (salt water fish or aholehole) that the holothurin extracted from the Cuvierian tubules of *Actinopyga mauritiana* is toxic in minute concentrations to aquatic organisms.

The heart and respiratory rates were compared with the size of the organisms. These rates appear to be directly related to each other for the prawns and opae and also appear to be independent of size for all organisms. There seems to be no relation between the size of these organisms and their susceptibility to the toxin. Instead, the time of death of the fish and prawns is directly proportional to the dilution utilized.

Holothurin seemed to act as a heart stimulant for both the prawns and opae since heart rate increased.

Tests with *M. lar*: The respiratory systems seems to be affected faster and more directly than the circulatory system since respiratory rate deteriorated faster than heart rate. It could be that in order to maintain a balance in body functions (in terms of oxygen and waste material exchange) the heart had to work harder to make up for the decrease in respiratory rate.

Tests with *P. debilis*: The opae died at a higher concentration than the prawns. There was also a delayed reaction to the toxin. This might indicate that the salt water shrimp, as opposed to the fresh water shrimp, may have developed a temporary immunity to the sea cucumber's toxin through adaptive radiation. This conclusion should be reinforced with further testing.

Tests with *K. sandvicensis*: Since the heart rate of the fish could not be directly measured, no comparison can be made between heart and respiratory rates. The steady respiratory rate until a short while before death perhaps indicates that the heart rate or nervous system deteriorated before respiratory rate.

The salt water fish seemed to be more susceptible to the toxin than the brackish water prawns or salt water shrimp as the aholehole died at lower concentrations. The susceptibility of the fish at a lower concentration than the prawns and opae signifies that the toxin has a stronger effect on the vertebrate organism because of its more advanced circulatory and nervous systems. Further study with other organisms on the relationship of the effect of holothurin on cardiac activity and respiratory systems between vertebrates and invertebrates should be conducted for repeatable evidence.

It could be that holothurin is more toxic to some marine organisms because the cucumber is also a marine animal and has adapted this defense to deal with its environment. This conclusion should be reinforced by further investigation with other animals.

Tests with Human Blood: It is evident that holothurin is a strong hemolytic agent since it lysed the red blood cells in a very minute concentration. It appears that holothurin acts upon not only the red blood cells but on the other components of the blood as well, as the percent transmittance, indicating the amount of blood tissue acted on, continues to increase after the cells have been broken up Also, the *number of cells with corresponding transmittance level from the dilution tests does not correlate with the number of cells in the same transmittance for the toxicity tests.*

The rate at which the blood is effected slows down as time increases probably because the amount of substrate left for the holothurin to act on decreases with time also. Tests with different dilutions could be made later on.

In the future, I wish to continue working with this toxin and run tests on other animals. Tests could extend to higher vertebrate animals with the use of the Oscilloscope that measures heart activity as in an electrocardiogram (EKG). The toxin might be compared with other heart stimulants such as adrenalin and oleander digitoxin. Toxins extracted from different species of cucumbers can be compared. The effect of aging on the potency of the toxin could be studied. Behavioral studies of the sea cucumber in its environment might be looked into. The use of holothurin as an antibacterial and biological control agent in a marine ecosystem can also be studied.

CONCLUSIONS

Based on the studies conducted, it appears that holothurin:

1) *acts as a heart stimulant for Macrobrachium lar and Palaemon debilis*
2) *has a stronger affect on Kuhlia sandvicensis than on the two species of shrimp*
3) *has a differential effect on the two species of shrimp (one brackish water-fresh water and the other salt water)*
4) *is a hemolytic agent on human blood tissue*

ACKNOWLEDGEMENTS

I am grateful to Mr. Ron Iwamoto and the rest of the SSTP staff, Mr. John Hawkins and Ms. Barbara Rogers for their time, patience, cheerfulness, enthusiasm, excellent advice and encouragement. Many thanks to all those who helped with the collection of cucumbers and gave assistance in the lab. Much appreciation goes to the NSF for the sponsorship of the SSTP, Chaminade College for the use of its facilities, and the 39 other NSF participants who made this past summer a truly great and invaluable experience. Finally, warmest MAHALO and ALOHA to my friends at McKinley who I've enjoyed working with.

REFERENCES

Baslow, M. H., (1969), Marine Pharmacology, Williams and Wilkins Co., Md., 184

Boolootian, R. A., (1966), Physiology of Echinodermata, Interscience Publishers N.Y., 10, 530

Buschbaum, R., (1938), Animals Without Backbones, Unibersity of Chicago Press, IL., 263

Chanley, J., Ledeen, R., Wax, J., Nigrelli, R. F. and H. Sobotka, (1959), Holothurin, A. J. Am. Chem. Soc., 81: 5180

Chanley, J., Mazzeti, T., and H. Sobotka, (1966), The Holothurinogens, Tetrahedron, 22: 1857

Edmondson, C. H., (1933), Reef and Shore Fauna of Hawaii, Bishop Museum, HI, 96, 212

Friess, S. L., Standaert, G. G., Whitcomb, E. R., Nigrelli, R. F., Chanley, J., and H. Sobotka, (1960), Some Pharmacologic Properties of Holothurin A, Annals N.Y. Academy of Sciences, N.Y., 893

Gosline, W.A. and V. E. Brock, (1960), Handbook of Hawaiian Fishes, U. H. Press, HI, 159

Hyman, L. H., (1955), The Invertebrates, Echinodermata, McGraw-Hill Book Co., Inc., N.Y., 121

Jordan, D. S. and B. W. Everman, (1973), The Shore Fishes of Hawaii, Rutland, VT, C. E. Tuttle Co., Japan, 155

Kolmer, J., (1944), Clinical Diagnosis by Laboratory Examinations, Appleton-Century-Crofts, Inc., N.Y., 977

Nigrelli, R. F. (1952), Effects of Holothurin on Fish and Mice With Sarcoma 180, Zoologica, N.Y., 37:89

Nigrelli, R. F. and R. A. Zahl, (1952), Some Biological Characteristics of Holothurin, Proceedings Soc. Exp. Bio. N.Y., 81: 379

Nigrelli, R. F., Chanley, J., Kohn, S. and H. Sobotka, (1955), The Chemical Nature of Holothurin, Zoologica, N.Y., 40: 47

Nigrelli, R. F. and S. Jakowska, (1960), Effects of Holothurin, Annals N.Y. Academy of Sciences, 90:884

Nohara, Charlene, (1974), Extraction of Toxic Materials from Indigenous Holothurians, NSF SSTP, Chaminade College of Honolulu, HI

Okada, Donna, (1975), Effect of the Toxin Holothurin on Lymphoma Cells, NSF SSTP, Chaminade College of Honolulu, HI

Schwab, J., (1964), Biology Teachers' Handbook, John Wiley and Sons, Inc., N.Y., 549

Worden, A. N. and W. Lane-Petter (ed.), (1957), The FAW Handbook on the Care and Management of Laboratory Animals, 2nd ed., Bailliere, Tindall andCox, London